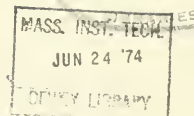


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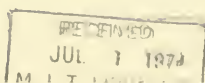
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Preface

The purpose of this report is to make available to interested people information on the existence and content of research going on in the Management Science Group of the Sloan School of Management. The report contains

1. Titles and abstracts of M.S.G. faculty publications for the period July 1971 through June 1972.
2. Abstracts of theses supervised by M.S.G. faculty during the same period.

If further information is desired about any specific item of research, it is requested that the individual authors be contacted.

John D. C. Little

To order MANAGEMENT theses (give author, thesis title, S.M. or Ph.D., and year), write for estimate to: M.I.T. 14-0551
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Management Science Group Faculty

1971 - 72

Arnold E. Amstutz *
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Applications

PUBLIC MANAGEMENT

Family Planning

A STRATEGIC PLANNING MODEL FOR THE MANAGEMENT OF A FAMILY PLANNING SYSTEM, G.L.Urban, S.S.M. Working Paper # 572-71 (November 1971).

This paper describes a strategic planning model designed to be used by managers of family planning systems to improve understanding, forecasting, and planning. The macro-flow model describes the patient movement through post partum and non-post partum programs. The flows model the phenomena of: outreach, continuance, post partum check ups, switching methods, referral, migration, contraceptive use experience, private protection, method effectiveness, follow up, and abortion. Strategic variables can be linked to the flow parameters to produce capacity requirements and budgetary implications. The model output includes benefit measures of total actives, couple years of protection, "Births protected," and unwanted births prevented. The fertility aspects of births prevented are modeled through a non-stationary Markov process submodel which considers demographic phenomena without burdening the basic flow structure. The input procedures used to process service statistics, outreach, clinic survey, and experimental data are discussed. The combination of data based estimates and subjective judgment is done by "fitting" the model to past observed data. Testing is done by "tracking" model performance through conditional prediction, diagnosis, and updating.

The model is programmed on a soft ware system called EXPRESS so that evolutionary model building can take place. A simple model with two contraceptive methods, two agencies, and a homogeneous target group can be structurally modified on-line to have, for example, four methods, five agencies, and two target group segments. Evolution also allows new phenomena such as abortion, advertising, or private protection to be added on-line. The concept is to build a "decision calculus" that is understandable to managers, complete, evolutionary, easy to use, easy to control, robust, and adaptive.

The paper includes a discussion of how the model could be used in goal setting, policy determination, and budgeting and allocation. An application and testing of the model to the Atlanta Area Family Planning System is discussed and the experiences of managers in using the model to gain new insights, forecast, budget, and plan are reported.

USING A MODEL AS A PRACTICAL MANAGEMENT TOOL FOR FAMILY PLANNING PROGRAMS, Ronald W. O'Connor and Glen L. Urban, S.S.M. Working Paper #562-71 (October 1971).

Managing a family planning system is a difficult and complex task. Managers attempt to answer questions such as:

What have been the past sources of success and failure in our programs?

Where is the system going?

What resources will be needed to support system growth? What budget should be sought and how should funds be allotted?

How can a diverse group of clinic service agencies be coordinated?

A great deal of data exists to help answer such questions. Even a single agency or clinic program is confronted by a variety of data sources including client visit records, outreach worker reports, budget figures, target population estimates, opinions and survey findings. These inputs are compounded when there are several programs or agencies involved in the political realities of one area. In fact, the complexity of the information presents a problem to the manager who must make sense out of the data before he can use it to help in his decision making.

This paper describes an application of management science through the use of a model as a tool for program managers and areawide planners to grapple with the inundation of potentially important data. The goals of this model are to improve understanding of how a particular family planning system operates and to support improved program management through the organized use of data in problem diagnosis, forecasting, and examination of strategy alternatives.

VISIT CONTINUATION RATES, INTERVISIT TIMES, AND THEIR MANAGERIAL IMPLICATIONS TO FAMILY PLANNING ADMINISTRATORS: A CASE STUDY OF ATLANTA, P. A. Naert and S. Murthy, S.S.M. Working Paper #560-71 (October 1971).

Family planning time survival rates have been applied extensively to evaluate the effectiveness of various methods or programs. Visit continuation rates have received less attention. In this paper it will be argued that visit continuation rates are of great usefulness to the family planning administrator. Relevant dimensions along which to segment the family planning population with regard to visit continuation rates are investigated. After studying the distribution of inter visit times, various management decision areas are discussed where visit continuation rates can help the family planning administrator. The areas considered are forecasting and planning, evaluation of program changes and program effectiveness, allocation of follow up effort, and finally, policy decisions.

Citizen Feedback

CITIZEN FEEDBACK COMPONENTS AND SYSTEMS, John D. C. Little, Thomas B. Sheridan, Chandler H. Stevens, and Peter Tropp, Technical Report No. 76, Operations Research Center (June 1972).

Citizen feedback may be defined as information from citizens directed to societal institutions, especially government, in order to improve their functioning. Citizen feedback can be divided into two broad categories: service feedback includes inquiries, requests, and complaints; involvement feedback includes opinions, suggestions, and participation. Correspondingly, citizen feedforward is information projected to citizens, who can then provide feedback based on their values and judgments.

The project studied citizen feedback components and systems in the context of live problems in Massachusetts. Four main areas were considered:

(1) Service feedback was studied in the Executive Branch and recommendations for improving the quality and timeliness of responses to citizen communications were developed. As part of this effort, a time-shared computer was programmed to do case accounting; that is, to keep track of incoming citizen communications, to classify them, and to provide summary reports and reminders about open cases. A survey of citizen satisfaction with the Governor's response to letters was also undertaken.

(2) Two promising involvement feedback techniques were tested: the technology-aided meeting, or listening post, and the issue ballot. These were applied in the Department of Education's project on setting educational goals for Massachusetts. Twelve listening posts were conducted and the technique was found to increase the productivity and vitality of the meetings. About 13,000 issue ballots were distributed through various media including two local newspapers. In one case this was coordinated with a cable TV program.

(3) Interactive models on a time-shared computer were studied as a technique for citizen feedforward. Two models were built, one to analyze tuition changes at state colleges and the other to study formulas for state financial aid to local schools. It was found that a model can be useful for such applications provided that its assumptions can be grasped quickly and its calculations readily understood.

(4) The results of the above studies were used to develop design guidelines for a state-wide citizen feedback/community dialog system. Such a system would be coordinated by a state Communications Commission and would have service feedback and involvement feedback subsystems. The service feedback side would include a Citizen Feedback Unit in the Governor's Office which would provide technical assistance and help establish response guidelines for more extensive feedback operations in secretariats and individual agencies. The involvement feedback subsystem would develop and carry out plans for stimulating community dialog and action on selected topics. Prototype plans call for participatory television, newspaper issue ballots, and local meetings with technological aids as appropriate.

Productivity in the Food Industry

A POSITIVE PROGRAM FOR PRODUCTIVITY, G.F.Bloom, Supermarketing, June 1972.

This article, written specially for an issue dealing with the problem of productivity and inflation in good prices, makes a number of concrete suggestions which the food industry can follow to improve its efficiency.

PRODUCTIVITY IN THE FOOD INDUSTRY: PROBLEMS AND POTENTIAL, G.F.Bloom, M.I.T. Press: Cambridge, Mass., 1972.

This book stresses the need for a systems approach to the problem of improving productivity in the food industry and examines the impact of institutional, technological, and competitive factors upon manhour output in this industry.

THE SYSTEMS APPROACH TO IMPROVED PRODUCTIVITY, G.F.Bloom, submitted as article for fall issue of The International Journal of Physical Distribution.

This article makes the point that in the years ahead the major opportunities for acceleration in the rate of productivity will be found in the field of physical distribution; that the key area is the inter-firm, rather than intra-firm, locus; and that the changing nature of technological development will to an increasing extent require industry consensus and joint industry agreements with respect to standardization in order to effect major breakthroughs in productivity.

Negro Employment

THE NEGRO IN RETAIL TRADE, G.F.Bloom and F. Marion Fletcher and Charles Perry, University of Pennsylvania Wharton School of Finance and Commerce, Philadelphia, Pa. 1972.

This book contains a comprehensive analysis of the changing status of the Negro in three important segments of retail trade: supermarkets, department stores, and drug stores. The analysis indicates how differing marketing practices, location, and other factors have produced major variances in the percentage of employemnt of Negroes in these industries.

THE NEGRO IN THE SUPERMARKET INDUSTRY, G.F.Bloom and F. Marion Fletcher, University of Pennsylvania Wharton School of Finance and Commerce, Philadelphia, Pa. 1972.

This monograph examines policies and trends in the supermarket industry affecting Negro employment, particularly during the period 1960 to 1970. Original survey data and EEOC statistics are utilized. The volume also contains a detailed analysis of the experience of black owned and operated supermarkets in ghetto areas.

Consumer Durables

ESTIMATING THE TIMING AND MAGNITUDE OF PEAK SALES IN NEW CONSUMER DURABLES, Warren H. Hausman and Kanak K. Chopra, S.S.M. Working Paper #590-72 (February 1972).

Consider the problem of estimating the timing and magnitude of peak sales for a new consumer durable product which is infrequently purchased and initially has few replacement purchases (as compared to initial purchases). In such a case typically the sales rate climbs to a peak over a period of years and then declines somewhat, with replacement purchases becoming a larger component of total sales and initial purchases correspondingly declining. A good estimate of the magnitude of the peak sales rate is a critical input to production capacity expansion planning, while a good estimate of the timing of the peak sales rate is critical to proper control of inventories as sales attains and passes its peak rate. We explore a model proposed by Bass for this situation, pointing out a possible shortcoming and suggesting a modification of his model which involves a decision-theoretic approach.

Energy

TWO STOCHASTIC MODELS USEFUL IN PETROLEUM EXPLORATION, Paul G. Bradley and Gordon M. Kaufman, Second International Symposium on Arctic Geology.

The process of exploring for oil and gas is rich in uncertainties. Any attempt to forecast returns to investment in exploration must take them into account in a systematic way. By this we mean that inferences about the important uncertain quantities characterizing the exploration process should be based on a mathematical model whose parameters may be estimated from observable data in a coherent way. At the root of any useful model of the exploration process, then, is a set of assumptions that delineate in clear unambiguous terms the probability law governing the manner in which observable data is generated.

Our first objective is to construct a model of the exploration process t hat allows us to test empirically the hypothesis that at an early stage

in the exploration of a basin, the process behaves like sampling without replacement. The model we posit is parsimonious--based on a small number of assumptions and indexed by only five parameters. The set of assumptions on which it is built reflects at least two qualitative assertions often made by oilmen: the "big ones" tend to be found first and the size distribution of fields is highly skewed. We may use it to compute answers to two questions of paramount importance in designing exploration strategy:

(1) How does the probability that a wildcat well will find a reservoir change (if at all!) as the history of a basin unfolds?

(2) What is the probability that a yet-to-be-drilled wildcat well will find a reservoir of a given size or greater at a given point in the development of a basin?

Our second objective is to posit a reasonable model of the spatial distribution of petroleum reservoirs that conforms to a number of empirically observed facts about such distributions, but does not possess three unrealistic attributes that characterize models of spatial occurrence appearing in the literature: dependence of the model on arbitrary subdivision of a basin into units of subspace, the assumption of spatial homogeneity of the stochastic process operating within each such unit as well as across units, and conceptualization of a reservoir as a point (in the plane) rather than as an object with positive area.

PRIVATE NON-PROFIT ORGANIZATIONS

Health Clinics

AN AUTOMATED MEDICAL HISTORY SYSTEM: EXPERIENCE OF THE LAHEY CLINIC FOUNDATION WITH COMPUTER-PROCESSED MEDICAL HISTORIES, John F. Rockart, Ephraim R. McLean and Philip I. Hershberg, S.S.M. Working Paper # 592-72 (March 1972).

Since the late 1940's, efforts have been made to assist the physician in the time-consuming task of collecting medical history information. More recently, computer technology has been employed in the design of automated medical history systems. Researchers at a number of different locations have tried several approaches including the use of prepunched cards, keypunched or mark-sensed forms, and on-line terminal-based interview systems.

At the Lahey Clinic, an automated medical history system (AMHS) has been in operation since 1968 and as of the present time has been administered to over 30,000 patients. The system was designed to aid in patient scheduling, to assist the physician in his history taking, and to provide a data base for research studies.

The present Questionnaire is a 25-page booklet which is mailed to the patient at his home in advance of his appointment. The completed Questionnaire is mailed back to the Clinic where the booklet pages are optically scanned and processed by the computer. The resultant print-out is placed in the patient's medical record folder where it serves as the primary history document.

Although the Lahey system shares much in common with other computer-based history systems, it also has a number of distinctive features. These can be briefly be summarized as follows:

1. The original development and operation of the AMHS was funded from the operating revenues of the Clinic.
2. It is a routine, integral part of the Clinic procedure and is administered to almost all new patients who come to the Clinic.
3. Because of the desire to use the results for advanced scheduling purposes, the Questionnaires are filled out by the patients at their homes.
4. The success of the system is due in large measure to the use of an interdisciplinary approach joining the skills of the physician, management scientist, and computer specialist.
5. By design, the AMHS is an evolutionary system. The present Questionnaire is the fourth version, and plans are already underway for the fifth version.
6. Accompanying these developmental activities is a strong commitment to continuing research and evaluation. Some of the studies which have already been conducted have dealt with physicians' attitudes, patients' attitudes, and content validity.

A METHOD OF DETERMINING WHICH MEDICAL RECORDS SHOULD BE STORED IN THE 'ACTIVE FILE,' John F. Rockart, S.S.M. Working Paper # 593-72 (March 1972).

As the numbers of patients seen by medical facilities increase, the question of which medical records to keep "active" has become increasingly important. Limited storage space forces the development of a decision rule to be used to separate active from inactive records. With the advent of computer-stored records and the need to utilize most effectively costly direct-access storage, the question of which records should be considered to be active has become significant for an additional reason. This paper presents a method to define, more precisely than existing methods, those records which should be stored in the active file--either the physical medical record file or the computer-stored record file.

Computer Aided Decision Making

COMPUTER ANALYSIS OF DIAGNOSTIC AND THERAPEUTIC STRATEGIES, G. Anthony Gorry, Proceedings of Electronic and Aerospace Systems Conference, 1971, 89-94.

An interactive computer program has been implemented for the analysis of diagnostic and therapeutic problems. This program employs formal decision procedures and the subjective assessment of likelihoods and preferences of experts to analyze these problems.

This paper discusses the development of this program and presents the results of an experiment using it to make decisions in acute renal failure.

The program's success in duplicating the decisions of expert clinicians in about 90 percent of the cases used indicates that the method of analysis is not only a convenient structure for theoretically describing diagnosis and treatment, but that it is potentially a practical way of analyzing such decision problems.

DECISION ANALYSIS AND CLINICAL JUDGMENT, William B. Schwartz, G. Anthony Gorry, Alvin Essig and Jerome P. Kassirer, S.S.M. Working Paper # 605-72 (June 1972).

Sound clinical judgments derive both from the command of a sufficient body of facts and from the skill to combine such facts appropriately. Most undergraduate and graduate medical education concentrates on the first of these elements, the acquisition of knowledge--little formal effort is

directed to the logic of dealing with clinical problems.

In the present discussion we suggest that the theory and techniques of decision analysis provide new and useful strategies appropriate for dealing with complex clinical situations. In their qualitative aspects these formal strategies closely resemble those that the expert clinician employs informally, but which he is often unable to communicate explicitly. When applied quantitatively, the formalism affords greater precision than is otherwise readily attainable.

To illustrate the application and utility of decision analysis we have considered the problems posed by several severely hypertensive patients with possible functional renal artery stenosis, and have examined, both qualitatively and quantitatively, the alternative courses of action available to the clinician.

DECISION ANALYSIS AS THE BASIS FOR COMPUTER-AIDED MANAGEMENT OF ACUTE RENAL FAILURE, G. Anthony Gorry, Jerome P. Kassirer, Alvin Essig, and William B. Schwartz.

In recent years many attempts have been made to use the computer as an aid to diagnosis, but little has been done to exploit the potential of computer technology as a more general aid to decision making. In the present report we describe the use of the discipline of decision analysis as the basis for an experimental interactive computer program designed to assist the physician in the clinical management of acute oliguric renal failure. The program deals with alternative courses of action, either tests or treatments, for which the potential risks or benefits may be large, and it balances the anticipated risk of a given strategy against the anticipated benefit that it offers the patient. The appraisals of the different courses of action open to the physician are expressed in quantitative terms as expected value. The program has been evaluated by comparing its recommendations to those of experienced nephrologists in eighteen simulated cases of acute oliguric renal failure. Agreement between the nephrologists and the program was found in more than 90 percent of instances, but the experiments identified a series of problems that must be resolved if the program is eventually to be widely useful as a "consultant." It has been found, for example, that it will be necessary to develop strategies for dealing with multiple diseases occurring simultaneously, with signs and symptoms that frequently are not independent of one another, with changes in the pattern of a disease over time, and with the weighing of priorities for carrying out tests and treatments. We conclude that computer-aided management with the aid of decision analysis is a promising area for further investigation.

Education

AN INTEGRATED USE OF AVAILABLE RESOURCES (STUDENT, PROFESSOR AND TECHNOLOGY) IN THE LEARNING PROCESS, John F. Rockart, S.S.M. Working Paper # 601-72(May 1972).

The educational literature has recorded many individual advances in technique over the past few years. Self-study courses have been developed. Programmed instruction has been used. Interactive computer programs have been developed. Professors have learned to change dry lecture techniques to more stimulating class discussion. However, in most cases, these advances have been applied one at a time.

The course design discussed here sprang from the understanding that the diverse learning objectives which underlie a well rounded and well

structured course lead to the utilization of many classes of learning material. These in turn demand diverse learning methods to be utilized--with each type of material being matched by its most effective learning method and "delivered" by its most efficient resource--professor, student or technology. The implementation of this concept is reported in this paper.

The result was an integrated use of the available learning methods and resources--synergistically utilizing the best of each resource in the learning process. Measurable increases in student performance on examinations, course quality (as expressed by students), and academic productivity all resulted.

ASSOCIATIVE LEARNING PROJECT IN COMPUTER ASSISTED INSTRUCTION, John F. Rockart, Michael S. Scott Morton and Zenon S. Zannetos, Educational Technology, November 1971.

During the past two years, the Management Information for Planning and Control group at the Sloan School of Massachusetts Institute of Technology has been developing and experimenting with a new approach to computer assisted instruction at the college level. Built around a computer-driven interactive terminal linked to an "associative" memory with flexible search procedures, the system is aimed at providing (a) solutions to some critical problems that we believe are evident today in the field of education, and (b) a research tool for gaining insights into the nature of the learning process itself.

The purpose of this article is to consider both the objectives and techniques of the project. The emphasis, however, will be on the latter, as a complete description of the philosophy which underlies the current work is available in a recent publication.

The following paragraphs will discuss, in order, the basic objectives of the present system, the characteristics necessary for the next generation of learning systems, the operational objectives of the present system, the hardware which is being utilized, and the basic structure of the software which comprises the associative learning system itself. The emphasis throughout this article has been placed on allowing the reader to understand what is being done and why it is being done rather than on explaining the programming details of the system.

THE EQUALIZATION OF SCHOOL EXPENDITURES IN MASSACHUSETTS, Charles B. Stabell, Jerrold M. Grochow, Anders Haan, S.S.M. Working Paper #606-72 (June 1972)

This is a report of the results to date of a project concerned with the financing of primary and secondary education in the Commonwealth of Massachusetts. The central concern is the illustration of those aspects of the current system and proposals which have a bearing on the accomplishment of stated objectives. In particular, the objective with which we are most concerned is that of equalization between school districts of average school expenditures per child within school districts. The project has identified a number of problems with the existing system of state aid and with some of its central assumptions. In order to overcome these difficulties and develop a better system, a number of new areas of study are proposed.

BUSINESS

Marketing

ADVERTISEMENT SIZE AND THE RELATIONSHIP BETWEEN PRODUCT USAGE AND ADVERTISING READERSHIP, Journal of Marketing Research, Alvin J. Silk and F. Geiger, Volume 9, No. 1 (February 1972) 22-26.

This study investigated the hypothesis that the association between prospect status and exposure to print advertising decreases as advertisement size increases. Two definitions of prospect status were used. First, the distinction was made between users and non-users of the type of product which the advertised brand represents. Secondly, among users of the product type, recent users of the advertised brand were differentiated from those who had used some other brand. These two measures were separately related to advertisement noting and reading scores for 99 advertisements that appeared in a British magazine. Contrary to the hypothesis, non-linear relationships were found between advertisement size and the magnitude of usage-exposure associations. Selective processes appeared to affect advertisement reading more than noting.

ADVERTISING BUDGETING AND GEOGRAPHICAL ALLOCATION: A DECISION CALCULUS APPROACH, Glen L. Urban, S.S.M. Working Paper #532-71, (Revised January, 1972).

This paper proposes a model for use by managers in setting advertising budgets, deciding how much money to spend in national media, and allocating local advertising expenditures between markets. It is designed to fulfill Little's decision calculus criteria for implementation. The model includes consideration of inter-area heterogeneity due to growth rate, advertising response, media, profit margin, distribution, competition, and carryover effects. The model operates in an on-line setting and a heuristic programming approach is used to aid managers in finding the best solutions. The thrust of the paper is towards integrating model building with data estimation and implementation. A longitudinal application discusses the successes and failure over three years that lead to experimental design as a basis for estimation, usage of the model in decision making, and profitable managerial implementation.

A MULTIPLE-PRODUCT SALES FORCE ALLOCATION MODEL, David B. Montgomery, Alvin J. Silk and Carlos E. Zaragoza, Management Science, Vol. 18, No. 4, Part II, (December 1971).

When several products are marketed by the same sales force, it frequently becomes impossible or impractical for salesmen to promote all items in the product line extensively in each and every time period. Management's problem is to decide how the available selling effort should be allocated across products and over time. The opportunity costs associated with using limited selling resources to promote certain products but not others must be evaluated. This paper describes a decision calculus-type modeling system for dealing with this question.

The problem is analyzed by a two-step procedure. First, a response function is defined which relates selling effort to sales and profit results in a manner which represents some behavioral phenomena considered

to be important. An interactive conversational program elicits judgmental data from managers which are used to parameterize the response model. A separate response function is specified for each product in the firm's line by this method. The set of response functions so obtained becomes the input for the second component of the system, an allocation heuristic. An incremental search procedure is employed to find an allocation of the sales force's time to the various products and over several time periods which is "best" in terms of total contribution to company profits. The model is presented in the context of an ethical drug manufacturer's multiple-product sales force allocation problem. Results of an application are summarized and implementation considerations noted. A comparison of the model-based allocation with that determined previously by management indicated that the former plan would offer a substantial improvement in profits.

AN INTERACTIVE MEDIA DECISION SUPPORT SYSTEM, David Ness and Christopher R. Sprague, S.S.M. Working Paper #595-72 (March 1972).

Media planning consists of (1) establishing a desired market; (2) finding media (in particular, periodicals and television shows) which reach that market; and (3) allocating advertising funds to these media. This paper discussed the design, implementation and operation of an interactive, terminal-based computer system which manages a large data base and provides models that aid the advertising decision maker in solving this problem.

APPLICATION OF A FLEXIBLE SYSTEM TO RETRIEVE, MANIPULATE, AND DISPLAY INFORMATION FROM A STABLE, QUESTIONNAIRE-ORIENTED DATA BASE TO SOCIAL SCIENCE RESEARCH, David Ness and Christopher R. Sprague, S.S.M. Working Paper #594-72, March 1972.

The needs of managers making media allocation decisions have led to the establishment of a number of syndicated services selling data (demographic, media habits, and product consumption) derived from very detailed questionnaires administered periodically. Where there are enough users to support on-line storage charges, these data can be retrieved much more economically in a time-shared environment than in batch, and interactive systems with this capability are now in existence.

Such an interactive system would be of considerable utility to a researcher interested in any relatively stable questionnaire-oriented data base, the U.S. Census, for example. The syndicated data bases themselves may also be of considerable value in some research.

This paper describes such a data base, and an interactive system giving access to it. A simple study involving the relationship between total income and sources of non-employment income is described.

BRANDAID: AN ON-LINE MARKETING-MIX MODEL, John D. C. Little, S.S.M. Working Paper #586-72, February 1972.

Marketing managers make decisions about price, advertising, promotions, and other marketing variables on the basis of factual data, judgments, and assumptions about how the market works. BRANDAID is a flexible, on-line model for assembling these elements to describe the market and evaluate strategies. The structure is modular so that individual decision areas can be added or deleted at will. The model has an aggregate response form. By this it is meant that the effects

of decision variables are related closely to specific performance measures such as market share and product class sales. Retail distribution and competition can be considered explicitly.

Model implementation is viewed as a multiple step process and divided into introductory and on-going periods. The introductory period includes orienting management, forming a team, selecting and formulating a problem, calibrating the model and initial use. The on-going period includes firefighting, tracking and diagnosis, updating and evaluation, and re-use.

The calibration of the model is approached eclectically. Steps include judgment, analysis of historical data, tracking, field measurement, and adaptive control. Illustrative examples are given.

A two-year case study is described.

In conclusion, the emerging role of the model in the marketing management process is discussed. The model is seen not only as a means of evaluating strategies in annual planning and day to day operations but also as part of a monitoring system which compares model predictions with actual sales to uncover marketing problems and opportunities and to focus managerial attention upon them.

CLUSTERS OF CONSUMER INTEREST AND SPHERES OF INFLUENCE OF OPINION LEADERS, Alvin J. Silk (with D. B. Montgomery), Journal of Marketing Research, Vol. 8, No. 3 (August, 1971), 317-321.

This paper reports a test of the hypothesis suggested by King and Summers that opinion leadership overlaps between topics when interest in them also overlaps. Patterns of association in opinion leadership for sixteen topics were found to correspond to the structure of interrelationships among measures of interest in the same topics.

ESTIMATING THE DYNAMIC EFFECTS OF MARKETING COMMUNICATIONS EXPENDITURES, Alvin J. Silk (with D. Montgomery), Management Science, Vol. 18, No. 10, (June, 1972).

This paper is concerned with the problem of measuring market response to a "communications mix" -- the various means which a firm employs to transmit sales messages to potential buyers. Distributed lag models are applied to time series data for an ethical drug to estimate the short-run and long-run effects on market share of expenditures made for journal advertising, direct mail advertising and samples and literature. Important differences were found among the communications variables with respect to the magnitude and over-time pattern of effect each had on market share. The managerial implications of the findings are discussed.

INTERACTION AND INFLUENCE PROCESSES IN PERSONAL SELLING, Harry L. Davis and Alvin J. Silk, Sloan Management Review, Vol. 13, No. 2, (Winter, 1972).

When stock is being taken of the current state of marketing knowledge, one frequently hears it said that personal selling is a neglected area of study. The point is usually made that despite its generally greater significance as a marketing expense than media advertising, personal selling has been the object of much less modelbuilding and empirical study. There are, however, indications that the situation is changing. The amount of attention being paid to sales force management problems in the management science/operations research literature appears to be increasing. Sales operations are also the focal point of much of the work going on in the area of marketing information systems.

This paper reviews some relevant developments of yet another sort -- behavioral research on personal selling. A great deal of research on the behavior of salesmen has been conducted in the past, but most of it has dealt with psychological testing and the prediction of salesmen's performance. A quite different point of view is reflected in the material examined here. Our interest centers on efforts to apply social psychological knowledge about interaction and influence processes to selling problems.

LOGICALLY CONSISTENT MARKET SHARE MODELS, P. A. Naert and A. Bultez, S.S.M. Working Paper, No. 607-72, (June, 1972).

This paper analyzes restrictions on explanatory variables, parameters and disturbances imposed by sum-constrained dependent variables.

The logical consistency of market shares models is then examined.

MEASURING PERFORMANCE IN A DECENTRALIZED FORM WITH INTERRELATED DIVISIONS: PROFIT CENTER VERSUS COST CENTER, Philippe A. Naert.

Two problems arise in the decentralization of a firm with interrelated divisions. First, there is the possibility that the overall objectives of the firm are not optimized when individual divisions try to optimize their own performance. The question of assuring maximum overall profitability for the firm has been studied extensively in the literature on transfer pricing. The objective of this paper is to provide insight in a second problem, less often raised but equally important, namely, given a transfer pricing mechanism that maximizes overall company profit, should divisional performance be measured on a profit or on a cost basis.

OBSERVATIONS ON APPLYING MARGINAL ANALYSIS IN MARKETING: PART I, Philippe A. Naert.

In applications of marginal analysis in marketing, the economic interpretation of the results is often incomplete and in various places incorrect, resulting in suboptimization. Various problems related to correct economic interpretation are discussed and are then applied to some empirical studies.

ON SUBOPTIMIZATION IN DECOMPOSITION APPROACHES TO TRANSFER PRICING, Philippe A. Naert and Christian T. L. Janssen, Journal of Industrial Economics, Vol. 19, No. 3, (July, 1971).

The possibility of suboptimization in a decentralized form through one division acting as a monopsonistic buyer, or another division as a monopolistic seller, in the internal transfer of goods was explored by Hirshleifer. The case under discussion is the so-called joint level of output case. Hirshleifer's solution implied that one division possessed marginal cost information about the other division. (Two divisions were assumed for simplicity.) Decomposition approaches to transfer pricing have not been concerned with this suboptimization problem, as it would be avoided by precluding interdivisional exchange of marginal cost information. In this paper we show that even in the absence of marginal cost information about the selling division, the buying division can, under certain conditions, benefit by behaving as a monopsonistic buyer. Specifically, the buying division can maximize its divisional profit at the expense of the profit for the firm as a whole. The analog is true for the selling division acting as a monopolistic seller. It is then not sufficient for the purpose of avoiding suboptimization simply to prevent interdivisional exchange of marginal cost information.

OPTIMIZING MARKETING ADVERTISING, INTERMEDIARY ADVERTISING AND MARKUP IN A VERTICAL MARKET STRUCTURE, Philippe A. Naert, Management Science, Vol. 18, No. 4, Pt. II, (December, 1971).

Given is a vertical market structure (VMS) which consists of producers, one intermediary level and consumers. In most of the literature on VMS either equilibrium behavior is studied without consideration of objectives or some objective function is being optimized without taking into account behavior of intermediaries. This paper is a modest attempt to bring the two approaches together. The decision variables are consumer advertising, intermediary advertising and markup offered by producers to intermediaries. Behavior of intermediaries is incorporated through the use of a pseudo-decision variable, the equilibrium number of middlemen in the VMS.

OPTIMIZING MARKETING MIX DECISIONS: AN ECONOMIC ANALYSIS, Philippe A. Naert.

In recent years there has been a substantial number of applications of economic analysis in studying marketing mix decisions. The general approach has been to use econometric techniques to estimate model parameters, and micro economic analysis in interpreting the results. Palda and Lambin have studied monopolies. Telser, Lambin, Schultz and others have studied various types of oligopolies. In this paper a more general optimal allocation model will be presented of which these applications are all special cases. This more general model also provides a link between Telser's earlier work and more recent work by Lambin.

PRIVATE SECTOR FOOD DISTRIBUTION AND NUTRITION, G. F. Bloom, U.S. Nutrition Policies in the Seventies, John Mayer, ed.

This article is one of a series written specially for this volume by experts in the field of food distribution and nutrition. The article, which appears as Chapter 15 in the volume, examines the difficulty which supermarkets face in attempting to market nutritious foods in view of the changing economics of the business. Attention is also given to the problem of food distribution for low income families.

RESPONSE SET AND THE MEASUREMENT OF SELF-DESIGNATED OPINION LEADERSHIP, Alvin J. Silk, The Public Opinion Quarterly, Vol. 35, (Fall, 1971).

The internal consistency and discriminant validity of the items comprising the Rogers self-designating opinion leadership scale were investigated utilizing notions suggested by Campbell and Fiske's multi-trait-multimethod matrix approach to establishing convergent and discriminant validity. While the items were shown to be highly inter-correlated, their ability to discriminate consistently between two types of opinion leaders was found to be limited and there were indications that trait-irrelevant method factors have a substantial effect on scores obtained on the scale. Acquiescence response set appeared to be present when the scale was used to identify opinion leaders for one type of activity, but did not appear operative when the scale was administered to the same sample with reference to a different category of behavior. This suggests that the types of response bias which may affect the Rogers scale and the extent of their influence depend on the area of opinion leadership to which the scale is applied. Randomizing the order in which response alternatives are presented and/or providing a neutral response category may help control some of the unwanted response bias.

Production and Operations Management

A NOTE ON THE BERGSTROM-SMITH MULTI-ITEM PRODUCTION PLANNING MODEL, Warren H. Hausman and John O. McClain, Management Science, Vol. 17, No. 11, (July, 1971).

This note demonstrates that the model proposed by Bergstrom and Smith (B & S) for deterministic multi-item production planning can, with some reinterpretation, be used to solve two related stochastic multi-item production planning problems. Specifically, the benefits of individual item-by-item treatment and diminishing marginal revenue contained in the B & S model can be obtained when future sales are (i) stochastic and uncontrollable, or (ii) stochastic but with the mean value under the control of the firm. We demonstrate that under both of these situations the certainty-equivalence property holds, thereby reducing the two stochastic problems to two related deterministic problems.

COORDINATING AGGREGATE AND DETAILED SCHEDULING DECISIONS IN THE ONE MACHINE JOB-SHOP: I-THEORY, L. Gelders and P. R. Kleindorfer, SSM Working Paper #600-72, (April 1972).

This research presents a formal model of the one machine job shop scheduling problem with variable machine and labor capacity. Primary interest is focused on the trade-off between overtime and detailed scheduling costs. The detailed scheduling problem considered is minimizing the sum of weighted tardiness and weighted flow-time costs for a given capacity plan (e.g., a given overtime schedule). Sequence theory results are generalized to this case where possible. Various lower bounding structures for the problem are analyzed and a preliminary branch and bound algorithm is outlined. Several interesting features of the algorithm and bounding structures are illustrated by an example. Extensions of the results to more complex environments are discussed.

INVENTORY CONTROL WITH PROBABILISTIC DEMAND AND PERIODIC WITHDRAWALS, Warren H. Hausman and L. Joseph Thomas, Management Science, Vol. 18, No. 5, Pt. I, (January, 1972).

Many manufacturing firms produce component parts both for assembly into new products and to meet orders for spare parts. An inventory model for this situation would involve two types of demands: probabilistic demand as spares and deterministic (or scheduled) withdrawals as components for assembly. Relevant costs would include a setup cost for replenishment orders, inventory carrying costs, and backorder costs. An analytical model approximating these characteristics is formulated. An optimal dynamic program for the periodic review case is briefly discussed; this policy is extremely costly to implement, however. Two feasible operating policies are considered in the paper: a continuous review (Q,r)-type policy and the heuristic policy for a set of numerical examples.

LINEAR CONVEX STOCHASTIC OPTIMAL CONTROL WITH APPLICATIONS IN PRODUCTION PLANNING, Paul R. Kleindorfer and Keith Glover

Linear stochastic systems with convex performance criteria and convex, compact control regions are studied. The admissible control region is assumed to be a continuous function of the (perfectly) observed state. Optimal feedback controls are shown to exist within the class of Borel measurable functions of the present state. Using dynamic programming the optimal return function is shown to be convex. Generalization

of the results to quasi-convex cost functions is discussed and asymptotic results for stable systems are derived. These results are then used to explore several problems in aggregate production and workforce planning. Computational aspects of the results in the context of the smoothing problem are discussed.

MULTIPRODUCT PRODUCTION SCHEDULING FOR STYLE GOODS WITH LIMITED CAPACITY, FORECAST REVISIONS AND TERMINAL DELIVERY, Warren H. Hausman and Rein Peterson, Management Science, Vol. 18, No. 7, (March, 1972).

A general mathematical model is formulated for the problem of scheduling production quantities for a group of products with seasonal stochastic demand through a common production facility. It is assumed that revised forecasts of total demand over the season for each product become available as the season progresses; delivery is not required until the end of the selling season. Limited production capacity requires that some production take place early in the season, when forecasts are less accurate. At the end of the season, there are overage costs and underage costs representing costs of producing excess quantities and opportunity costs of not producing enough units. Under certain assumptions concerning the data-generating process for forecast revisions, it is possible to formulate the entire problem as a dynamic programming problem; however, the formulation is not computationally feasible if two or more products are considered. Three heuristic approaches to the multi-product problem are presented, and their cost performance is evaluated in some numerical examples. In these particular examples, more frequent reforecasting and rescheduling produces substantial reduction in costs.

MULTISTAGE PRODUCTION FOR STOCHASTIC SEASONAL DEMAND, W. B. Crowston, W. H. Hausman, and W. R. Kampe II, S.S.M. Working Paper No. 587-72, (April, 1972).

We consider the problem of production planning for a seasonal good which is produced in a multistage manner (e.g., when one or more components must be produced or purchased with a lead time that is long compared to the sales season). During the selling season, lost sales occur if demand cannot be satisfied; at the end of the season, leftover inventory incurs the usual overage cost. As the season progresses, the forecast of total demand is revised in light of current sales. The problem is to determine production quantities of the various components and assemblies at each period to minimize expected costs of underage and overage. If delivery is not required until the end of the selling (or "order-taking") season, then a dynamic programming formulation can produce the optimal decision rule. However, for the case in which delivery is required during the season, the associated dynamic programming formulation is computationally infeasible. The paper explores four heuristics for the latter problem and compares their cost performance in a numerical example. The most sophisticated heuristic produces expected profits which range from 3.2% to 5.5% of an upper bound on expected profit.

OPTIMAL MACHINE REPLACEMENT BY LINEAR PROGRAMMING, J.F. Shapiro and J.S. D'Aversa, S.S.M. Working Paper # 609-72 (August 1972).

The problem of an optimal strategy of machine replacement over an infinite horizon is formulated as a linear programming problem. Computational experience on real data is given including sensitivity of the LP solution to the maximum life of the machine and to various parameters of the model including discount factor, the method of computing depreciation, maintenance and rebuild costs.

Finance

THE RESOLUTION OF INVESTMENT UNCERTAINTY THROUGH TIME, Harold Bierman, Jr., and Warren H. Hausman, S.S.M. Working Paper # 567-71 (October 1971).

Investments in operating assets with identical expected discounted return and identical risk characteristics (i.e., variances and higher moments) when measured at the outset may have significantly different patterns of uncertainty resolution over their lives. The concept of uncertainty resolution, although ambiguous, is a potentially important characteristic of an investment alternative. This paper explores the usefulness and limitations of the concept of uncertainty resolution in the evaluation of both single risky investments and in portfolios of risky investments. In cases where future investment opportunities are completely known the concept does not seem useful; however, in a more realistic setting where future investment alternatives are ill-defined at present, the concept may prove useful. Further research is needed to explore fully the questions raised here.

METHODOLOGY

Systems Analysis/Model Building

AN EMERGING PROCESS OF BUILDING MODELS FOR MANAGEMENT DECISION MAKERS, Glen L. Urban, S.S.M. Working Paper # 591-72, (March 1972).

This paper draws on the literature in management science, behavioral science, and information systems along with practical experience to propose a process of building models that will be implemented. The steps are: (1) formulation of priors, (2) entry, (3) problem finding, (4) specification of model development criteria, (5) model building, (6) estimation and fitting, (7) tracking, and (8) continuing use. After describing the state of the art of model implementation, each factor is discussed. The paper closes with a preliminary identification of research needs in this area.

OPERATIONS RESEARCH AND SYSTEMS ANALYSIS IN THE PUBLIC SECTOR, Paul R. Kleindorfer, The Bell Journal of Economics and Management Science, Vol. 3, No.1, Spring 1972.

This review considers principally the books of de Neufville and Stafford and Wagner with an emphasis on their contribution to the theory and practice of systems analysis in the public sector. After some general remarks on the nature of operations research and systems analysis, a rough framework is given to structure problem areas of interest. The books in question are then briefly outlined. Finally, some comments are offered with respect to their contribution in terms of the framework presented.

THE DEVELOPMENT OF MANAGERIAL MODELS, G. Anthony Gorry, Sloan Management Review

Many managers are spending valuable time trying to solve the wrong problem or a non-existent problem. They often make decisions based on misinformation or faulty assumptions about how their system works. In the hope of improving managerial decisions, systems analysts and data processing departments continue to look for ways to improve the quality and quantity of information supplied to managers. This article takes a hard look at the other half of the decision making process: the model of the environment used by the manager. It shows how the development of a simple descriptive model helped the management of a large manufacturing firm find the right problems to solve. The article concludes with a discussion of the importance of managerial models in the decision making process.

Decision Making Behavior

ACCOUNTING TIME SERIES AS EVIDENCE OF UNIVERSITY STRATEGY AND STRUCTURE, Jarrod W. Wilcox, S.S.M. Working Paper # 568-71 (October 1971).

The strategic management of large organizations is impeded by the massive complexities to be analyzed. New approaches are needed to make possible a sharper focus on the key variables. The Treasurer's Report of the Massachusetts Institute of Technology offers a wealth of data amenable to statistical analysis. This paper illustrates multivariate methods for using these data to obtain evidence as to an organization's structure and modes of response to environmental disturbances.

Because of the ready availability of financial data the study emphasizes problems largely financial in character.

A METHOD FOR MEASURING DECISION ASSUMPTIONS, Jarrod W. Wilcox,

This book is meant to help find out why people make some choices rather than others. It asks of its reader some basic knowledge of statistical methods. Since it cuts across normally separate fields, it requires an adventuresome spirit. In return, one may expect to gain a tool of broad and varied uses in his own social science research and practical projects.

The message is on two levels. On one, the book is a practical handbook for application. On the other, it discusses fundamental issues in the theory of decision-making and the social sciences.

A SURVEY FORECAST OF NEW TECHNOLOGY IN UNIVERSITIES AND COLLEGES, Jarrod W. Wilcox, S.S.M. Working Paper # 585-72 (January 1972).

A simplified Delphi questionnaire was mailed to technologists and to a broad national sample of college and university faculty, librarians, and controllers. The responses yield predicted dates of adoption for various kinds of technologies. The technologies predicted are those thought most likely to have an impact on learning experiences within existing campuses, on the relative predominance of differing types of institutions, and on the structure of individual colleges and universities.

THE PRACTICAL JUSTIFIABILITY OF "IRRATIONAL" AVERSION TO RISK, Jarrod W. Wilcox, S.S.M. Working Paper # 597-72 (April 1972).

It is often necessary to explicitly confront cognitive limitations in prescribing appropriate decision-making behavior. One aspect of this general dictum is illustrated by showing that cognitively limited decision-makers may justifiably express greater risk-aversion in solving local problems than that allowed by current utility axioms. This occurs, for example, where strong externalities do not allow a satisfactory formulation of the event space. Consequently, the imposition of the expected utility hypothesis may sometimes be counter-productive. It is recommended that specific costs for risk be used to patch-up the "holes" in the choice space created by such externalities.

Statistics and Stochastic Processes

A WEAK CONVERGENCE THEOREM FOR ORDER STATISTICS FROM STRONG-MIXING PROCESSES, Roy E. Welsch,

This paper provides sufficient conditions for the weak convergence in the Skorohod space $D^d[a,b]$ of the processes $\{(Y_{1,[nt]} - b_n)/a_n, (Y_{2,[nt]} - b_n)/a_n, \dots, (Y_{d,[nt]} - b_n)/a_n\}$, $0 < a \leq t \leq b$, where $Y_{i,n}$ is the i th largest among $\{X_1, X_2, \dots, X_n\}$, a_n and b_n are normalizing constants, and $\langle X_n : n \geq 1 \rangle$ is a stationary strong-mixing sequence of random variables. Under the conditions given, the weak limits of these processes coincide with those obtained when $\langle X_n : n \geq 1 \rangle$ is a sequence of independent identically distributed random variables.

BOUNDING DISTRIBUTIONS FOR STOCHASTIC LOGIC NETWORKS, George B. Kleindorfer and Paul R. Kleindorfer, March 6, 1972.

A stochastic logic network is defined as a connected set of logic and time delay elements. Each of the latter elements has an associated probability distribution describing the nature of that element's delay. When used, for example, in project planning and scheduling, combinations of logic and time delay elements in such networks may represent conditions for the starting of project activities which are themselves represented by time delay elements. It is at present not known how to calculate the probability distributions for the events in such a network. This paper shows how to obtain upper and lower bounds for these probability distributions. The method is not a simulation technique; rather, it is a straight-forward computational scheme derived from elementary probability theory. Examples are given wherein the method is applied to a simple stochastic flip-flop network and a stochastic project scheduling network in which alternative ways exist for carrying out one of the jobs in the network.

LIMIT LAWS FOR EXTREME ORDER STATISTICS FROM STRONG-MIXING PROCESSES, Roy E. Welsch, S.S.M. Working Paper # 533-71, (May 1971).

This paper considers the possible limit laws for a sequence of normalized extreme order statistics (maximum, second maximum, etc.) from a stationary strong-mixing sequence of random variables. It extends the work of Loynes who treated only the maximum process.

The maximum process leads to limit laws that are the same three types that occur when the underlying process is a sequence of independent random variables. The results presented here show that the possible limit laws for the k th maximum process ($k > 1$) from a strong-mixing sequence form a larger class than can occur in the independent case.

OPTIMAL SERVICE POLICY FOR THE M/G/1 QUEUE WITH MULTIPLE CLASSES OF ARRIVALS, James S. Kakalik, John D.C. Little, (September, 1971).

Consider an M/G/1 queue with multiple classes of customers, non-preemptive service, and a cost of waiting. Suppose that the server can select next any customer present or can remain idle; and that this decision can be made as a function of the complete state of the system, i.e., the number of each class of customer present. The objective is to minimize the stationary expected cost rate. Let $1/\mu_i$ be the mean service time and C_i be the waiting cost per unit time for class i customers. The optimal policy is shown to be: Never hold the server idle when customers are present; and serve next a customer with the largest value of $C_i \mu_i$ among those present. This policy is Cox and Smith's priority class rule generalized to apply to any state of the system and to a much broader class of allowable decisions. The result is obtained by formulating the problem as a semi-Markov decision process and solving the corresponding linear program.

POSTERIOR INFERENCE FOR STRUCTURAL PARAMETERS USING CROSS-SECTION AND TIME SERIES DATA, G. M. Kaufman, OR 007-71 (December 1971), (Written for the Session on Bayesian Analysis of Simultaneous Equations Models, World Congress of the Econometric Society, Cambridge, England, September, 1970.)

A study is made of an explicit Bayesian analysis of a simultaneous equation system when both time series and cross-section data are available. We assume that the process generating time series data is the usual set of stochastic equations

$$\underline{B}\underline{y}^{(j)} + \underline{\Gamma}\underline{z}^{(j)} = \underline{u}^{(j)}, \quad j=1,2,\dots \quad (1)$$

where $\underline{B}(\text{mxm})$ non-singular and $\underline{\Gamma}(\text{mxr})$ are coefficient matrices, fixed for all j , $\underline{z}^{(j)}(\text{rx1})$ is a vector of $\underline{r}$ predetermined observable variables and $\underline{y}^{(j)}$ and $\underline{u}^{(j)}(\text{mx1})$ are random vectors. In particular we assume that $\{\underline{u}^{(j)}\}$, $j=1,2,\dots$ is a sequence of mutually independent identically distributed Normal random vectors with mean 0 and variance matrices $\underline{\Sigma}$, and that neither $\underline{B}$, $\underline{\Gamma}$, nor $\underline{\Sigma}$ are known with certainty. The system may be re-expressed in reduced form

$$\underline{y}^{(j)} = \underline{\Pi} \underline{z}^{(j)} + \underline{\epsilon}^{(j)}, \quad j=1,2,\dots \quad (2)$$

when $\underline{B}$ is non-singular, where $\underline{\Pi} \equiv -\underline{B}^{-1}\underline{\Gamma}$ and $\underline{\epsilon}^{(j)} = \underline{B}^{-1}\underline{u}^{(j)}$. Defining $\underline{Y} = [\underline{y}^{(1)}, \dots, \underline{y}^{(N)}]$, $\underline{Z} = [\underline{z}^{(1)}, \dots, \underline{z}^{(N)}]$, and

$$\underline{M} = \begin{bmatrix} \underline{Y} \underline{Y}^t & \underline{Y} \underline{Z}^t \\ \underline{Z} \underline{Y}^t & \underline{Z} \underline{Z}^t \end{bmatrix},$$

the likelihood function for $\underline{B}$, $\underline{\Gamma}$, and $\underline{\Sigma}$ is

$$|\underline{\underline{B}} \underline{\underline{B}}^t|^{-1/2N} e^{-1/2 \text{tr} \underline{\underline{\Sigma}}^{-1} [\underline{\underline{B}} \underline{\underline{\Gamma}}] M [\underline{\underline{B}} \underline{\underline{\Gamma}}]^t | \underline{\underline{\Sigma}}|^{-1/2N} \quad (3)$$

The identification problem is essentially one of determining structural parameters from those of the reduced form. Its Bayesian counterpart is that time series observations generated according to (1) do not alter a posteriori the prior conditional density of $\underline{\underline{\beta}}$ given reduced form parameters. Cross-section data bearing directly on elements of $\underline{\underline{B}}$ and $\underline{\underline{\Gamma}}$ clearly will.

We explore properties of $\underline{\underline{\beta}}$ and $\underline{\underline{\Gamma}}$ posterior to observing cross-section data bearing on individual rows of $(\underline{\underline{\beta}} \underline{\underline{\Gamma}})$ under two differing sets of assumptions. The first is: observations bearing on row i of $(\underline{\underline{B}}, \underline{\underline{\Gamma}})$, $(\underline{\underline{B}}_i \underline{\underline{\Gamma}}_i)$, are generated according to an independent Normal regression process with residual error variance $\underline{\underline{v}}_i$, $\underline{\underline{v}}_i$ a nuisance parameter unrelated to structural parameters. This process is independent of the process generating time series data; in addition, the processes generating observations bearing on individual rows $(\underline{\underline{B}} \underline{\underline{\Gamma}})$ are mutually independent. The second assumption varies from the first only in that the regression process generating cross-section data bearing on $(\underline{\underline{B}}_i \underline{\underline{\Gamma}}_i)$ has residual error variance proportional to σ_{ii} , the i^{th} diagonal element of $\underline{\underline{\Sigma}}$.

Under the assumption that cross-section residual error variances are not related to the time series variance matrix $\underline{\underline{\Sigma}}$, the marginal density of $(\underline{\underline{\beta}} \underline{\underline{\Gamma}})$ has components in the form of a product of (multivariate) Student kernels -- poly-t kernels. Posterior poly-t densities have been studied by Tiao and Zellner, Dickey, and appear also in Chetty. We show that under certain circumstances the marginal posterior density of the reduced form parameter $\underline{\underline{\eta}}$ is proportional to a ratio of matrix poly-t densities. This ratio bears an interesting relationship to the posterior density for a single row of $\underline{\underline{\beta}}$ that Drèze uses to derive a Bayesian version of a LIMLE estimator when cross-section residual error variances are proportional to corresponding time series error variances.

Using the same data as Drèze, we compute the posterior mode of parameters in the demand equation of Tintner's model of supply and demand for meat, poultry, and fish. While purely illustrative in nature, the computations indicate that the procedure is surprisingly robust given that there is a substantive difference in specification of the model for cross-section data used by Drèze and that used in our calculations.

SIMULTANEOUS EQUATION SYSTEMS VIEWED BAYESIANLY -- AN EXERCISE IN EXOTIC DISTRIBUTION THEORY*, Gordon M. Kaufman, Written for a conference held at the University of Navarra, Barcelona, Spain (June 1970).

An enormous literature dealing with problems of inference about the parameters of structural (simultaneous) equation systems blossomed soon after Haavelmo's (1947) initial conception of the relevance of such systems for economic analysis. From 1947 until 1962, all of the methodological machinery developed for making inferences about parameters of structural systems was based on the premise that one cannot make (subjective)

probability statements about fixed but unknown parameters of a stochastic model. Then in a seminal article Jacques Dreze (1962) laid the groundwork for a treatment of structural equation systems from a Bayesian point of view. He pointed out that most econometricians traditionally eschew the principle that one can in fact quantify subjective judgments about uncertain quantities in a meaningful way which jives nicely with the rules of probability. As a consequence, they are forced to resort to the most extreme sort of a priori judgments in order to make meaningful inferences about parameters of structural equation systems. Namely, to assert that with probability one each member of a subset of the parameters of the system has a particular value! This apparent paradox is but one of many reasons why a Bayesian view of inference in this particular context is compelling. Zellner (1965) has effectively summarized a battery of arguments in favor of the Bayesian approach:

- (1) Prior information can be processed in a well-defined mathematical fashion via Bayes Theorem.
- (2) Exact finite sample size results in the form of posterior densities can usually be computed.
- (3) There is a natural way of handling nuisance parameters: "integrate them out."
- (4) The analysis of the effects of departures from model assumptions can be conveniently done.
- (5) Most prediction, decision, and control problems can be framed quite naturally in Bayesian terms, and in fact in many applications it is the natural way.

Yet, by comparison with the flood of publications that flowed soon after 1947 -- all of it aimed at developing more traditional modes of inference -- the number of articles elaborating the Bayesian viewpoint during the past eight years is a mere trickle.

To explain why, one might cite a number of recurrent points of conflict in the battle that still rages between traditionalists (of the Neyman-Pearson, Fisher camp, say) and Bayesians. But in view of the necessity for imposing some kind of prior judgments in order to make inferences about structural parameters, many econometricians are in fact preconditioned to accept the notion of subjective probability as having pragmatic relevance in such problems. As a consequence, many of the usual traditionalists' arguments against use of subjective probability lose force.

There are, however, a number of other substantive barriers to be hurdled before a well-rounded practical Bayesian theory of inference for this problem can be built. One is due to the tyranny of large numbers: in general, the number of parameters in a structural system with m equations is at least $1/2(3m^2 + m)$. Thus for large m one must assess a joint prior for a huge number of parameters. (Anyone who has attempted an honest assessment of subjective probabilities for three or more non-independent uncertain quantities knows how mind-boggling the problem can become. Many authors dodge this difficulty by appeal to Jeffrey's invariance principle; this leads to other difficulties as we shall see.) Another is that in order to implement a Bayesian treatment of structural equation systems, an econometrician needs a kit of technical tools rather different from those already in the tool box of most practicing econometricians. That is, the distribution theory is somewhat exotic.

In this paper we shall review certain Bayesian accomplishments, using as an illustrative vehicle a model that has no lagged exogenous variables nor autocorrelated errors. We will concentrate on properties of priors and of exact (finite sample size) posteriors; the reader is referred to Zellner (1965) for a discussion of large sample approximations from the Bayesian point of view and their relation to classical (non-Bayesian) large sample theory. Our purpose will be to touch on what has been done by Bayesians who have worked on the problem.

TWO DISTRIBUTIONS INVOLVING A BESSEL FUNCTION, G. M. Kaufman, Journal of the American Statistical Association, Vol. 67, No. 340 (December 1972).

Properties of the distribution of a certain sum of a Normal random variable and the reciprocal of a Gamma random variable are examined. This sum appears naturally in the course of doing a Bayesian analysis of the Lognormal process.

Mathematical Optimization

A GENERALIZED PROGRAMMING ALGORITHM FOR INTEGER PROGRAMMING PROBLEMS WITH MANY COLUMNS, Jeremy F. Shapiro, S.S.M. Working Paper # 556-71 (August 1971).

The generalized programming algorithm consists of major iterations and minor iterations; each major iteration consists of many minor iterations. A major iteration terminates with the addition of a Gomory cut. A minor iteration corresponds to the solution of a master linear programming problem and a group optimization problem. Activities can be deleted at the end of each minor iteration as the result of new lower bounds generated during the minor iteration. The algorithm allows most of the integer programming columns to be kept in secondary storage and evaluated in core one at a time.

THE MATHEMATICAL PROGRAMMING LANGUAGE (MPL), George Dantzig, Stanley C. Eisentat, Thomas L. Magnanti, Steven F. Maier, and Michael B. McGrath, Stanford University

The Mathematical Programming Language (MPL) is a high-level user-oriented programming language intended particularly for developing, testing, and communicating mathematical algorithms. Presented here is an introductory discussion of the language. The major emphasis is on the need for MPL, the resulting design philosophy, and those characteristics that make the language read like mathematics. An example has been included.

COMPUTATIONAL EXPERIENCE WITH A GROUP THEORETIC INTEGER PROGRAMMING ALGORITHM
G. Anthony Gorry and Jeremy F. Shapiro, S.S.M. Working Paper # 603-72 (June 1972).

This paper gives specific computational details and experience with a group theoretic integer programming algorithm. Included among the sub-routines are a matrix reduction scheme for obtaining group representations, network algorithms for solving group optimization problems, and a branch and bound search for finding optimal integer programming solutions. The innovative subroutines are shown to be efficient to compute and effective in finding good integer programming solutions and providing strong lower bounds for the branch and bound search.

CONSTRUCTIVE DUALITY IN INTEGER PROGRAMMING, Jeremy F. Shapiro and M. L. Fisher, MIT Operations Research Center Report OR008-72 (May 1972).

A new integer programming dual problem is constructed from a re-formulation of the integer programming problem. Properties of this integer programming dual problem are developed and it is shown that strong integer programming cuts and surrogate constraints can be derived from optimal dual solutions. A primal-dual ascent algorithm for solution of the integer programming dual problem is presented, and the use of this algorithm in branch and bound is explained.

RELAXATION METHODS FOR PURE AND MIXED INTEGER PROGRAMMING PROBLEMS,
G. Anthony Gorry, Jeremy F. Shapiro and Laurence A. Wolsey, Management Science, Vol. 18, No. 5, (January, Part I, 1972).

The usefulness of group theoretic methods in solving integer programming (IP) problems is extended by procedures for controlling the size of the groups. The main procedure given shows how an optimal linear programming basis can be altered to reduce the magnitude of its determinant thereby reducing the size of the group induced by the basis. An adaption of Benders' mixed IP algorithm is given which uses these methods. Some limited computational experience is given.

Information Systems

A FRAMEWORK FOR MANAGEMENT INFORMATION SYSTEMS, G. Anthony Gorry, Michael Scott Morton, Sloan Management Review, (Fall 1971)

A framework for viewing management information systems (MIS) is essential if an organization is to plan effectively and make sensible allocations of resources to information systems tasks. The use of computers in organizations has grown tremendously in the 1955 to 1971 period, but very few of the resulting systems have had a significant impact on the way in which management makes decisions. A framework which allows an organization to gain perspective on the field of information systems can be a powerful means of providing focus and improving the effectiveness of the systems efforts.

In many groups doing MIS work, this lack of perspective prevents a full appreciation of the variety of organizational uses for computers. Without a framework to guide management and systems planners, the system tends to serve the strongest manager or react to the greatest crisis. As a result, systems activities too often move from crisis to crisis, following no clear path and receiving only ex post facto justification. This tendency inflicts an unnecessary expense on the organization. Not only are costly computer resources wasted, but even more costly human resources are mis-managed. The cost of systems and programming personnel is generally twice that of the hardware involved in a typical project, and the ratio is growing larger as the cost of hardware drops and salaries rise.¹ Competent people are expensive. More importantly, they exist only in limited numbers. This limitation actively constrains the amount of systems development work that can be undertaken in a given organization, and so good resource allocation is critical.

Developments in two distinct areas within the last five years offer us the potential to develop altogether new ways of supporting decision processes. First, there has been considerable technological progress. The evolution of remote access to computers with short turnaround time and flexible user interfaces has been rapid. Powerful mini-computers are available at low cost and users can be linked to computer resources through inexpensive typewriter and graphical display devices. The second development has been a conceptual one. There is emerging an understanding of the potential role of information systems within organizations. We are adding to our knowledge of how human beings solve problems and of how to build models that capture aspects of the human decision making processes.²

The progress in these areas has been dramatic. Entirely new kinds of planning and control systems can now be built -- ones that dynamically involve the manager's judgments and support him with analysis, models, and flexible access to relevant information. But to realize this potential fully, given an organization's limited resources, there must be an appropriate framework within which to view management decision making and the required systems support. The purpose of this paper is to present a framework that helps us to understand the evolution of MIS activities within organizations and to recognize some of the potential problems and benefits resulting from our new technology. Thus, this framework is designed to be useful in planning for information systems activities within an organization and for distinguishing between the various model building activities, models, computer systems, and so forth which are used for supporting different kinds of decisions. It is, by definition, a static picture, and is not designed to say anything about how information systems are built.

In the next section we shall consider some of the general advantages of developing a framework for information systems work. We shall then propose a specific framework which we have found to be useful in the analysis of MIS activities. We believe that this framework offers us a new way to characterize the progress made to date and offers us insight into the problems that have been encountered. Finally, we shall use this framework to analyze the types of resources that are required in the different decision areas and the ways in which these resources should be used.

THE MANAGEMENT OF LARGE-SCALE COMPUTER SYSTEMS, Malcolm M. Jones

Most large-scale computer systems available today require a technically sophisticated cadre of people associated with them to make them effective in the organization of which they are a part. The manager of these computer-oriented people must be more than just a good technician. He must demonstrate effective management skills in order to ensure that the computer system properly serves its role to the host organization. Eleven different function areas are cited as being important to the successful management of a large-scale computer facility. The areas are:

1. Computer operations
2. Financial planning
3. System maintenance
4. Software development
5. Software documentation
6. System resource accounting
7. User assistance
8. User administaation
9. Long range planning
10. Personnel management
11. System security

Interactive Systems

IMPLICATIONS OF INTERACTIVE MODELS FOR ACCOUNTING RESEARCH, Michael S. Scott Morton, The Accounting Review, Supplement to Vol. XLVII, 1972.

This paper raises issues for accounting research that flow from the availability of conversational computer systems. It is not a rigorous treatment of the topic for computer specialists, but it is intended to identify some research horizons for the accounting profession. We first discuss, the outlines of the technological and conceptual changes that are underway. We then return to the major implications. In the Appendix is given a summary of an experiment using a conversational system; this experiment provides an actual illustration of some of the points we have been raising.

Abstracts of Theses

Supervised by Faculty of the
Management Science Group

1971 - 72

STATISTICAL ANALYSIS AND EVALUATION OF A SIMULATION STUDY
OF AN URBAN TRAFFIC NETWORK

by

Michel Alvarez-Correa

Submitted to the Department of Electrical Engineering on May 19, 1972,
in partial fulfillment of the requirements for the degree of Bachelor
of Science.

ABSTRACT

Due to the increasing popularity of the automobile in America , many problems have arisen in a diamic manner. The public and the government realize that unless drastic measures are taken, these problems will take catastrophical proportions. Almost all fields of knowledge are necessary to the resolution of traffic problems. Increasing interest is now being shown both by practicing traffic engineers and by theoreticians of various kinds, mainly mathematicians and statisticians. A way of dealing with the problem of congestion is improving the effectiveness of existing networks by the development of better control and routing schemes. This has been done successfully by simulating the network.

The main interest of my thesis is the evaluation of a program which simulates the traffic flow in a particular network in Cambridge. This was done by a statistical analysis of observations in the real network and the data generated by the computer simulation.

This thesis is divided into five chapters. The first two parts will be designed to enlighten the reader so as to provide him with a better understanding of the work following. The first chapter is a brief survey on the work which has been done in the theory of road traffic. The second chapter overviews the simulation model of Larry Lowry/Lukas Papademos. The third chapter describes the experiments done in the real network so as to obtain the necessary data for the analysis. The fourth chapter provides the reader with the appropriate theoretical framework for the statistical analysis of the processes under study, putting emphasis on autocovariance and spectral analysis. Finally in the fifth chapter, the comparison is made between the real network and the simulation model. My conclusions are that the model accurately approximates the real system but that the ultimate test for the model would consist in making a study of the network under a proposed traffic scheme and examine how accurately the simulation predicted the results.

Thesis Supervisor: John D. C. Little

Title: Professor of Operations Research and Management

SCHOOL DISTRICT MANAGEMENT -

A TRUSTEE VIEW

by

Fredrik E. Anderson

Submitted to the Alfred P. Sloan School of Management on May 12, 1972, in partial fulfillment of the requirements for the degree of Master of Science in Management.

ABSTRACT

Public education as practiced in the United States is a very large, complex, and important activity in society. Management of the approximately 17,000 autonomous operating entities called School Districts is carried out in an increasingly difficult environment by well intentioned but generally ill-prepared educators and lay trustees.

The purpose of this thesis is to study the management practices of several school districts from the point of view of a trustee. Thus, the investigation is directed at many diverse, but interrelated, aspects of management, including planning, decision making, and organizational behavior, but excluding the practices of the classroom teacher in dealing directly with students and their learning.

Observations and comments taken from public meetings of school district trustees and interviews with superintendents are integrated into structures that describe the nature of current management practices around selected issues or facets of operations. Consequences and/or dysfunctional aspects of these practices are developed and analyzed, followed by suggestions for improvement. Qualitative, interactive feedback system models are used to develop the former and illustrate the latter.

Thesis Supervisor: John Rockart

Title: Associate Professor of Management

ABSTRACTTHE DEVELOPMENT OF MANAGEMENT INFORMATION OR DECISION
SYSTEMS FOR A MUNICIPALITY

Dariush Ashrafi

Submitted to the Alfred P. Sloan School of Management on
May 12, 1972 in partial fulfillment of the requirements
for the degree of Master of Science.

The objective of the thesis is to provide a departure point and a survey of the field for the initiate in the application of information technology to the problems of the municipality. Rather than attempting to analyze the technical difficulties which may be encountered, this discussion focuses on those issues which can best be described as environmental. In line with this orientation, listing of the primary reasons for contemplating and implementing information systems in local governments is included. A summary of the available information is presented to show the achievements and direction of efforts by those cities presently involved in computerization. A more detailed examination is directed toward those areas which can be considered specific to local governments, with emphasis placed on those groups which are involved in solving the existing problems. Consideration is given to organizational difficulties which are usually encountered in the introduction of information technology. Finally, an evaluation of the ongoing projects is formulated with respect to their present organization and implementation.

Thesis Supervisor: David N. Ness

Title: Associate Professor of Management Information
Systems

THE APPROACH TO
PLANNING PROCESS FORMALIZATION

by

Douglas F. Bender

Submitted to the Alfred P. Sloan School of Management on February 11, 1972, in partial fulfillment of the requirements for the degree of Master of Science in Management.

ABSTRACT

Although the literature contains numerous theoretical discussions of the planning process, the need for planning, and the benefits to be expected from a formal planning system, it does not present sufficient practical guidance on how to translate these theoretical models of the planning process into an effective planning system within a company. As a result, each individual company has approached the task of planning process formalization with a minimum of practical normative guidance.

An attempt was made in this thesis to integrate and expand upon the existing practical knowledge. A descriptive model of the historical approach to planning process formalization was developed through a literature survey, and a field study in nine companies. Four major determinants of the structure of the formal planning system were evidenced: the size of the company, the role of the chief executive, the nature of the company, and the nature of the business.

Common aids and hindrances to the successful evolution of the formal planning system were highlighted in the cases studied. An analysis of these factors formed the basis for normative suggestions to guide future approaches to planning process formalization.

Thesis advisor: Zenon S. Zannetos
Title: Professor of Management

APPLICATION OF INTERACTIVE
DECISION AIDS IN
AGRICULTURE

by

H. GRANT BENNETT

Submitted to the Alfred P. Sloan School of Management
on May 18, 1972 in partial fulfillment of the requirements
for the degree of Master of Science.

ABSTRACT

This thesis considers some aspects of using interactive computer models to aid farmers' decision making. A framework is presented to give some order to the discussion of this relatively new area. It is then used to analyze model types, their need to be interactive and their impact on farm management. Criteria for programming the system is discussed and a prototype system which implements these criteria is presented. Some suggestions are made for the models and facilities required in an actual full scale implementation and the characteristics of problems where new models need to be developed are presented.

Thesis Supervisor: David Ness
Title: Associate Professor Management

ABSTRACT

AN INTERACTIVE DECISION SYSTEM TO SUPPORT
CAPITAL INVESTMENT DECISIONS UNDER RISK

Roy Thomas Burger, Jr.

Submitted to the Alfred P. Sloan School of Management on May 12, 1972 in partial fulfillment of the requirements for the degree of Master of Science.

Capital investment decisions are of great importance to the growth and profitability of a firm, and many techniques have therefore been developed to evaluate investment opportunities. All of these techniques, however, have serious shortcomings, and no single method of analysis is appropriate for every investment decision. In this thesis it is argued that an interactive decision support system can provide a particularly useful means of evaluating investment decisions. The inherent uncertainty and the lack of a reliable model for dealing with this uncertainty requires the effective use of executive judgment, and a well designed decision support system offers the executive an opportunity to improve his judgment. To test these ideas in practice, a decision support system was developed for a Boston area corporation, and this thesis describes the design considerations and the major features which were incorporated into this system.

Thesis Supervisor: David N. Ness

Title: Associate Professor

MATHEMATICAL ANALYSIS AND OPTIMIZATION OF A TWO-LEVEL
MULTIECHELON INVENTORY DISTRIBUTION SYSTEM

by

Robert Cann

Submitted to the Alfred P. Sloan School of
Management on May 12, 1972 in partial
fulfillment of the requirements for the
degree of Master of Science.

Abstract

The purpose of this thesis is to develop a mathematical model of a two-level inventory system. The particular type of inventory system to be modelled is a retailer-owned food wholesaling outlet. The basic approach used to develop the model was to derive the probability distribution of goods entering at the retail level and to use this distribution as the demand pattern for the wholesaler.

Another purpose of the thesis is to demonstrate how the model may be used as an analytical tool.

The model was implemented on the computer using data from a local retailer-owned wholesaling corporation. The results were analyzed and certain characteristics of the optimal solution were derived. It is hoped that the model and the approach used to develop the model will be of interest to those people interested in multiechelon systems.

Thesis Advisor: Philippe N.
Naert

Title: Assistant Professor
of Management

LONG-RANGE PLANNING MODEL FOR A CONSUMER FOOD COMPANY

by

JORDAN D. CARTER

Submitted in partial fulfillment of the requirements for the degree of Master of Science at the Massachusetts Institute of Technology, June, 1972.

ABSTRACT

Marketing managers make decisions about price, advertising, and promotions on the basis of factual data, judgments, and assumptions about how the market works. The long-range planning model is a vehicle for assembling these elements to describe the market and evaluate strategies. The planning model is flexible and modularly designed, so that individual decision areas can be added or deleted over time. The model relates the effects of the decision variables to specific performance measures: sales, market share, and profitability.

Calibrating the model is a key step in the process. Calibration involves judgment, analysis of historical data, and tracking the results over the historical time span being studied.

Although the long-range planning model is basically a marketing planning model, the results of the marketing analysis have implications for the entire planning process.

A case study application is presented, and a long-range planning model is developed for the company involved.

Thesis Supervisor: John D. C. Little
Title: Professor

ABSTRACT

THE MARKETING-MANUFACTURING INTERFACE

by

RONALD C. COLEMAN

Submitted to the Alfred P. Sloan School of Management on May 15, 1972 in partial fulfillment of the requirements for the degree of Master of Science.

One of the major responsibilities of the management of a modern industrial enterprise is to create effective interaction and integration of effort among the various functional groups that make up its organization. The achievement of effective collaboration toward overall company objectives, however, is hampered by the forces which motivate people to devote their primary efforts to the objectives of their individual disciplines. Increasing needs for differentiation, specialization and functional proficiency have created significant conflicts among the various functional groups which must be resolved if a company is to realize its true potential.

The purpose of this thesis was to single out the interfunctional conflict that exists between marketing and manufacturing and investigate it in the form of a subjective overview or staff study. The research methodology consisted of a review of the published literature on the subject coupled with a series of personal interviews with high level managers from sixteen industrial firms. The research was designed primarily to determine: (a) the relative significance of the marketing-manufacturing conflict, (b) the root causes of the conflict, and (c) what policies, techniques, and actions have proven to be useful in the management of the interface.

The study revealed that the marketing-manufacturing conflict was the most significant of all the interfunctional conflicts among the companies interviewed. The study also revealed that there are a number of approaches being followed by modern management as they grapple with the problem. Strategies to achieve effective interaction and integration at the marketing-manufacturing interface will involve a combination of modifications to a company's systems, its organization, and its psychological approach. While some generalization was necessary in relating the findings of this study it is obvious that corporations must design their own strategies for integration in relation to the demands of their markets, environments, personnel and objectives.

While the study revealed a wide range of opinion as to how the marketing-manufacturing interface should be managed, there was consensus that it should be approached aggressively and with great care and effort. Effective interaction and integration of effort at the marketing-manufacturing interface is now and will continue to be one of the prime requisites for the success of the industrial enterprise.

Thesis Supervisor: Gordon F. Bloom
Title: Senior Lecturer

A MULTISTAGE INVENTORY CONTROL CASE STUDY
IN A MASS PRODUCTION FACTORY IN THE UNITED KINGDOM

by

William Timothy Colman

Submitted to the Alfred P. Sloan School of Management on May 12, 1972
in partial fulfillment of the requirements for the degree of Master of
Science.

ABSTRACT

This paper analyzes an integrated multistage production inventory control problem involving one product range of a British manufacturer of mass produced non-ferrous valves for the heating industry. The company studied is Delta Engineers Brassfoundry Ltd., a subsidiary of the Delta Metal Co., Ltd. The chosen product range contains 20 valves used by the plumbing trade to terminate heating radiator panels. The products are sold from stock and subject to random and seasonal fluctuations. The range contains high and low demand items. The valves are assembled from 28 components.

The study is centered on the parts warehouse, situated in the production process immediately before assembly, and on the finished warehouse where completed valves are held prior to sale.

The existing monthly review system is modified so that orders for parts and for assembly into end products are placed in quantities close to optimal lot sizes.

Two safety stock policies are analyzed. The strategy of a high level finished product safety stock with long lead times and a dependent parts warehouse is compared with the strategy of a smaller product safety stock, shorter lead times and an independent parts warehouse with its own safety stock.

Seasonality is discussed by considering two extremes. The policy to maintain constant stock levels and seasonally adjusted production rates is compared with the policy to build stocks in anticipation of seasonal demand and keep production rates constant. The tradeoff between holding anticipation stocks at the parts and at the finished warehouses is also analyzed.

Thesis Supervisor: Warren H. Hausman

Title: Associate Professor of Management

OPTIMAL EQUIPMENT MAINTENANCE,
REBUILDING AND REPLACEMENT POLICY

by

Joseph S. D'Aversa

Submitted to the Alfred P. Sloan School of Management on May 12, 1972
in partial fulfillment of the requirements for the degree of
Master of Science

ABSTRACT

This thesis considers the ongoing decisions to replace, rebuild or maintain a given machine. An infinite horizon, dynamic programming model is used in which the purchase of a new machine corresponds to a point of regeneration. The goal is to maximize the infinite stream of discounted profits over the infinite planning horizon. The problem is recast in the form of a linear program. A particular example (a machine used in the coal industry known as a continuous miner) is solved with a standard linear programming computer package. The sensitivity of the solution to various parameters is tested. We conclude with some suggestions for further study.

Thesis Supervisor: Jeremy F. Shapiro
Title: Associate Professor of Operations Research
and Management
Associate Director, Operations Research Center

CORPORATE PLANNING MODELS IN THE OIL INDUSTRY
BY
OSAMU FUJISAWA

submitted to Alfred P. Sloan School of Management
on May 12th, 1972 in partial fulfillment of the
requirements for the degree of Master of Science

ABSTRACT

This thesis is concerned with the applicability of the models, qualitative or quantitative, in the corporate planning process. The oil industry and its corporate planning process has been chosen for specific analysis for two reasons. First is the conviction that a planning discussion has to include the context of a specific corporate setting to be meaningful. Secondly, the author has not only past experience but also a future career as a corporate planner in a major Japanese oil company.

The thesis starts with a review of planning literature and definitions, and a normative planning structure is identified as a basic framework for analysis. Within Anthony's taxonomy of the planning spectrum, examinations of the use of models in corporate planning lead the author to the hypothesis: (1) In the initial strategy formulation process, a qualitative model is preferred. (2) The use of quantitative models depends upon the degree of structure specificity of the particular strategic planning problem. (3) Where quantitative models can be applied, simulation models have greater applicability than optimization models in the evaluation of alternative strategies. (4) Within the management control process and especially for decisions involving long-range planning, quantitative models are useful. Optimization models are preferred for narrow scope problems such as functional and divisional planning, whereas simulation models are appropriate for more aggregate problems.

The degree of structure specificity is found to be the key factor or determinant for the use of quantitative models. The recent trends suggests the general direction of more frequent application of quantitative models in corporate planning.

The result of two published surveys on the use of quantitative models is presented, and the trend toward quantification of planning not only in management control but also in strategic planning is observed. The state of the art in corporate modelling and the sophistication of quantitative models in planning is also examined.

Moving to the actual situation, the result of an active field study in a certain oil company in the U.S. is discussed. The tentative hypothesis that the high degree of uncertainty in exploration and drilling phase of oil business operation hampers the practical use of quantitative models in strategic planning is tested. A corporate model in this

industry is, at present, more a guide for corporate planning than a powerful planning tool. However, the active application of linear programming models is identified especially for short-term management control in manufacturing, transportation and marketing.

The applicability of modelling techniques is further extended to the Japanese oil business, with a small case study of the planning system in a Japanese oil company. The author comes to the conclusion that more sophistication in quantification in corporate planning is recommended to Japanese oil companies where the degree of structure specificity in operation is lower than in American oil business. This is due to secure supply of raw material from international oil corporations by way of capital tieup as a result of no domestic oil production. In this area, a corporate model is likely to be a powerful planning tool. It is also observed that the tight governmental control on oil industry's operation is narrowing the scope of strategic planning to a great extent.

The above conclusion, both for American and Japanese oil business, is, inevitably, tentative. It is just one observation in a complex environment. The methodology throughout the thesis is a task-and-process oriented without due regard to the human factors of management in corporate planning. The author does not hesitate to mention this drawback of the thesis and it is felt that the human factors of corporate planning, especially the difference in managerial practice between American and Japanese corporations, is the another key determinant for the successful use of models in corporate planning.

Thesis Supervisor: Michael S. Scott Morton
Title: Professor of Management

IMPLEMENTING AGGREGATE PRODUCTION PLANNING

by

Dale Raimonde Geiger

Submitted to the Alfred P. Sloan School of Management on June, 1972, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE

ABSTRACT

This thesis is concerned with the lack of implementation of intermediate level, aggregate production planning models. The hierarchy of planning levels is discussed as are the development, purposes and procedures of various Aggregate Production Planning models. Although considerable academic interest has been dedicated to this planning function, implementation has not been forthcoming. This lack of usage paradox is explored and questioned.

The approach chosen by the author includes interviewing line production managers who would be intimately involved with and ultimately determinate of the success or failure of model implementation. Effort was also made to review the literature of systems implementation and model building to establish criteria for success. The results of these investigations are summarized as demands for greater realism and operationality considerations in APP modelling which now emphasizes only computational values.

The need for greater model realism is expressed in terms of the manufacturing manager/computer interface, forecasting, parochialism, information flows, labor relationships, communication problems, organizational structure, and technological process. The need for greater model operationality is expressed in terms of increased emphasis of practicality rather than optimality and in better model making procedures. Constraints imposed by the need for computability are expressed in terms of the ideal environment and production system.

Thesis Supervisor: Paul R. Kleindorfer
Title: Assistant Professor of Operations
Research and Management

SERVICE CONTRACTS AS AN INCENTIVE TO PRODUCT
DURABILITY, RELIABILITY AND MAINTAINABILITY

John Malcolm Greenwood

Submitted to the Alfred P. Sloan School of Management on
May 12, 1972, in partial fulfillment of the requirements
for the degree of Master of Science in Management.

ABSTRACT

A service contract is an agreement by one party to repair and maintain a product for a fee payment by the owner. This thesis examines the concept of a mandatory service contract offering by the manufacturers in the appliance industry. This is viewed as a possible incentive towards the production of more durable, reliable and maintainable appliances. The thesis first reviews the present economic factors which impinge on appliance manufacturers in deciding on the reliability and durability levels in their products. Then the economics of service contracting, the specific content of a possible service contract scheme and possible market effects are explored.

Thesis Supervisor: Warren H. Hausman
Title: Associate Professor of Management

ABSTRACT

DISTRIBUTION OF STEEL PRODUCTS IN ALGERIA

by

George L. Weill and Mohamed Haddadi

Submitted to the Alfred P. Sloan School of Management on May 12, 1972, in partial fulfillment of the requirements for the degree of Master of Science in Management

The Government Steel Company of Algeria (S.N.S.) has the monopoly of the importation and distribution of steel products in Algeria. S.N.S. is now in the process of organizing its distribution network and methods. This thesis studies the problems faced by S.N.S. and proposes solutions. Three areas are covered:

1. Warehouse location problem: the warehouse location methods described in the literature are reviewed with emphasis on their practical implementability. Recommendations are made concerning the actions S.N.S. should take about its warehouse location problem.
2. Servicing the (probabilistic) random demand from customers, for 2,000 products, through a multistage network of 23 warehouses: a simulation model of the distribution process is formulated, programmed and tested. It is shown that the model is a very flexible tool that can be used for effective managerial decisions concerning issues such as the configuration of the distribution network, the level and location of buffer stocks, and the control of the system's reaction to changes in demand.
3. Servicing the (deterministic) planned demand from other government companies and agencies: The Whitin and Wagner algorithm, which optimizes the ordering and stocking policy for the case of non constant deterministic demand, is computerized and applied to the S.N.S. case. The savings possible by pooling orders for the planned demand with the orders for random customer demand are then estimated.

Thesis Supervisor: Wallace B. S. Crowston

Title: Associate Professor of Management

AN EXPERIMENTAL GRAPHICS SYSTEM FOR SIMULATIONS

BY

KENNETH RENWICK HORNER

Submitted to the Sloan School of Management
on May 12, 1972 in partial fulfillment of the
requirements for the degree of Master of Science.

ABSTRACT

An experimental thesis to develop a testable graphics interface for the SIMPL Simulation Languages on the MULTICS computer system. The system produced dynamically updated graphs of model variables on an ARDS display station. The development is explained in detail and several test cases are used to clarify the operational details.

Thesis Supervisor: Malcolm M. Jones
Title: Associate Professor of Management

COMPUTER SIMULATION
OF
BOSTON FOOD COOPERATIVES

By

WILLIAM CHARLES HURD

Submitted to the Alfred P. Sloan School of Management on May 1, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

ABSTRACT

It is apparent that food is one of the greatest common needs among people, and by it also being one of the largest items in most family budgets, a study of low-cost food distribution systems seems feasible. In an effort to gain control of ones source of food, the notion of food cooperatives is an alternative source of food to the presently run food chains and large independent stores. Throughout the United States, and in particular the Greater Boston area, the idea of food co-ops is beginning to reassert itself.

As the investigation was being conducted, it was noticed that the goals and motivation of cooperatives were a great concern among co-op organizers and participants. The following goals represent a summary of their ideas: (The sources here include community leaders, actual proposals used by people starting cooperatives, social workers and leaders in community action agencies.)

1) Cooperatives are a forefront in which to create stable community-economic organizations that would be able to reduce the cost of living for families. Food is a good starting point because it is a necessity.

2) Cooperatives can be viewed as a learning process and also as promoting a sense of togetherness. Here, families in the communities could take an active part in food co-op operations and perhaps in other community affairs that would benefit all.

3) The cooperative is a practical way of dealing with the exploiters who prey on disadvantaged communities. It would serve as a mechanism through which food quality and prices could be controlled rather than depending on food chains for a "fair deal".

With the use of an on-line interactive computer system and the development of a general purpose simulation programming language called SIMPL on the MULTICS operating system, the impact of Boston area food cooperatives on the normal food distribution mechanisms was studied. This simulation

was used to observe hypothetical situations in which larger numbers of people than are currently participating in food cooperatives begin to participate. The results of study of these hypothetical conditions also show the effect on retail food trade in Boston. The ability to determine the optimal structure, size, location, etc. for individual food co-ops as well as the manner and degree to which they affect the pricing of food in retail and wholesale outlets was the major emphasis of this investigation.

It is recommended that food cooperatives expand, both physically and conceptually. Furthermore, food co-ops do have a legitimate role within the communities that seek less expensive food costs and a base for other community projects.

Thesis Supervisor: Malcolm M. Jones
Title: Assistant Professor of Management

A PRODUCTIVITY ANALYSIS OF A WAREHOUSING SUPPLY SYSTEM

by

W. H. KASTNING

Submitted to Alfred P. Sloan School of Management on May 1, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

Abstract

This thesis examines productivity measures and their application to comparative studies of corporate, functional and individual operations of a company. The study builds on previous productivity assessments undertaken by others and is directed at developing useful extensions of productivity concepts as an analytic tool. This assessment method provides management with unbroken, time-coherent measures that identify trends and relationships.

The study examines in detail a company's warehousing resource allocation and evaluates the resulting productivity performance. Data was gathered from numerous corporate documents which summarize annual changes for various time periods over the last eighteen years. The study was further supported by a number of visits and tours of selected warehouse locations, and included personal interviews with those responsible for the warehousing function.

The productivity study proposes for consideration areas for management emphasis in allocating and controlling warehousing resources and highlights the value of using productivity measures to further clarify and understand changing resource relationships and their effective interaction.

The approach used has general application and could be applied to a number of other corporate functions as an aid to analyzing an operation's resource application and as a tool in focusing on area for further productivity improvement.

Thesis Advisor: Dr. Gordon F. Bloom
Title: Senior Lecturer

AN OPERATIONAL SYSTEM DESIGN FOR CERVICAL CANCER SCREENING IN A PUBLIC HEALTH ENVIRONMENT

Gerald M. Katz

Submitted to the Alfred P. Sloan School of Management, M.I.T. in partial fulfillment of the requirements for the degree of Master of Science in Management, June, 1972.

ABSTRACT

This thesis is an application of a management science technique (simulation modeling) to a real world problem, that of designing a cervical cancer screening program (Pap Smears) to be instituted as a formal part of the family planning program in Tennessee.

The problem is stated explicitly, highlighting several specific questions:

- 1) How often should a women receive the Pap Test?
- 2) What are the effects of errors in reading the Pap smears?

This is followed by a detailed discussion of cancer of the cervix and the processes used for detection and treatment. The system is then modeled in flow charts, and mathematically, by a first order Markov process. The model is programmed using a time-sharing environment with a simple interactive capability. A possible set of inputs are presented and used to test a number of alternative strategies against a reference strategy. Given this hypothetical example, it is shown that neither a large false screening rate nor a longer inter-screening interval than the one generally used (one year) result in a marked increase in the number of deaths from cervical cancer; and the latter policy will result in a considerable monetary savings to the state. On the other hand, it is shown that the screening of women who have never had a Pap smear (or so long ago as to be insignificant) will greatly reduce the number of deaths. The thesis is concluded with a plea to collect and improve the data so as to increase the utility of the model as a decision tool.

Thesis Supervisor: Glen L. Urban
Title: Associate Professor
of Management

THE LEASE - PURCHASE PHENOMENON IN THE CAPITAL GOODS MARKET

by

MARVIN G. KIRBY

Submitted to the Alfred P. Sloan School of Management on April 14, 1972 in partial fulfillment of the requirements for the Degree of Master of Science in Management.

ABSTRACT

Once a firm has decided to acquire a capital good, the lease - purchase question becomes an important financial and economic issue. This study reviews the various types of lease and purchase alternatives, along with the qualitative and quantitative considerations which enter into the lease or purchase decision. Those considerations, believed to be the most important to the decision, are given detailed consideration. This includes a detailed review of the functions performed by the lessor, the effects upon the corporate financial statement, accounting practices, and tax considerations.

A review is made of the various methods available for analyzing the lease or purchase decision. A methodology is presented to assist in the solution of this problem, along with a discussion of the sensitivity of factors, such as methods of depreciation, residual value, and useful life.

The results of interviews with a number of users (of capital goods), manufacturers, and banks, indicated the primary consideration in the lease or purchase decision centered around the questions of obsolescence and short term financial considerations. The methods used to evaluate lease or purchase, and the quality of the decisions, while improving over the past few years, still leave a great deal to be desired in many cases. It appears that the leasing industry, while undergoing many changes, will continue to grow in size and importance in the capital goods market.

Thesis Supervisor: Edward H. Bowman
Title: Professor of Management

ABSTRACT

Title: Maximizing Communications in an R and D Laboratory Through Computerized Relative Allocation of Facilities

Author: Laurence Franklin Klurfeld

Submitted to the Alfred P. Sloan School of Management on May 12, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

The success or failure of the research and development laboratory depends in a large part on the ability of the organization to process large amounts of complex technical information. Due to the complexity of the information and the uncertainty of the user's needs, face-to-face communication is the most effective means of transmitting information within the organization. Allen [2] has found that the probability of a weekly face-to-face communication between two persons falls rapidly with separation distance. In fact, in the three organizations studied, probability of communication fell to nearly zero at the relatively small separation distance of 120 feet.

This thesis presents the problem of designing a layout for a laboratory to maximize communications in the framework of the quadratic assignment problem. A computerized relative allocation of facilities heuristic is presented for designing a layout that positions persons who should communicate near each other (so they are more likely to communicate). The technique employs the pairwise exchange algorithm to search the possible layouts for the best one.

The technique was used to design a layout for a 33-man group at Edo Corporation. The resultant layout improved a weighted measure of communications by 22 percent over the actual layout.

Conclusions about the applicability of the method in facilities design and about facilities design in general are presented.

Thesis Supervisor: Wallace B. Crowston

Title: Associate Professor of Management

MARKETING COMPUTER TECHNOLOGY TO HOSPITALS:

A Study of the Innovation-Decision Making Process

by

ZWI KOHORN

Submitted to the Alfred P. Sloan School of Management on May 12, 1972,
in partial fulfillment of the requirements for the Degree of Master of Science.

ABSTRACT

Marketing cannot be an exact science, depending as it does on the reactions of diverse and complex human beings over whom the seller has no immediate influence. To improve marketing techniques, the need is for greater knowledge of the individuals who make up the particular sellers' market. It is not just how many there are, but how they think, feel, and act in relation to change in general, and to the sellers' product in particular.

This study presents the details of one attempt to achieve such an understanding. It is a qualitative market research study focused on the hospital industry. The reason for selecting this particular industry as an object of the study is the desire to help in the broad national objective of meeting the current and well-documented crisis in health care. The specific objective of the study is to obtain a detailed picture of the innovation decision-making process as it occurs in hospitals (the process through which an individual or a group of individuals progress from first knowing about an innovation, to a decision to adopt or reject, and to confirmation of this decision). The focus is primarily on applications which could benefit from computer technology. It is our hope that the results of this study will encourage a better understanding by government, industry, and the health care delivery sectors, of the concerns and needs of hospitals.

To set the scene, a survey of the health care industry was first conducted. This survey suggests first, that delivery of health services does not occur in the framework of a conventional competitive market. Secondly, government involvement in delivery of health care is increasing, implying a regulatory dimension in the future. And third, hospitals, even though principally responsible for the spiraling costs, are here to stay as an institution no matter what health delivery system will prevail in the future.

Hospital needs are then discussed; specifically the needs for handling over-all communications, medical, and financial patient information. The available computer systems to serve those needs are described with specialized systems

(making use of computers to deal exclusively with a particular hospital application) holding the greatest promise for the future.

To understand the evaluation and choice criteria used by hospitals, we next examine the decision-making process. A framework consisting of five inter-related categories and an index of innovativeness were developed to analyze interview and questionnaire data from a total of 206 short-term, primarily non-profit, general hospitals. It appears that hospitals have difficulty defining goals and objectives, and are principally motivated by prestige, competition, and ego boosting. In hospital acquisitions, economic or functional considerations are of lesser importance.

Response to crisis is by far the predominant method of operation. Issues are resolved by a bargaining process in which the aggressiveness of the various pressure groups rather than a logical choice between clearly stated alternatives determines the outcome. The system of dual authority involving the administrative hierarchy and the physicians, further aggravates this irrational environment. The powerful, highly independent physician is the central figure in the hospital, wielding most of the power and pressing the administrator for more equipment and facilities in a constant drive to improve "quality" of health care. The administrator (non physician), lacking authority over the professional staff and often lacking technical know-how, has an impossible job running the hospital. The trustee is the only one who can balance the power of the physician. However, in a disagreement, he is constantly subject to a threat by the physician who may take his private patients elsewhere.

To tie in the ever rising costs of bed-days with the role conflict between the medical staff and the administrator, a model is offered illustrating the "Quality vs. Quantity Trade-Offs" (the basic bargaining issue between these two groups). The model suggests that one way to alleviate this role conflict and, at the same time hold the line on the cost of bed-days, is to improve technology in the hospital.

Finally, several factors, external to the hospital, are identified which could develop into sources of support for the administrator in his capacity as hospital manager. A strategy is also suggested for the computer industry to improve dealings with the hospital market.

Thesis Supervisor: Arnold E. Amstutz,
Committee: John F. Rockart,
Milton L. Lavin,

Senior Lecturer
Associate Professor
Assistant Professor

HOW DO MANAGERS OPERATIONALIZE GOALS?

by

Pierre-Yves Lejeune

Submitted to the Alfred P. Sloan School of Management on May 12, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

ABSTRACT

The essential task of a manager is decision-making. Theories and techniques have been developed to enhance managerial decision-making capabilities. A normative theory of decision-making has been put forward. However this normative-rational approach has been challenged. It has been suggested that this so-called normative theory is neither an accurate descriptive model nor a valid prescriptive one. The debate can be represented by two approaches to decision-making: the rational-deductive approach and an approach designated as disjointed incrementalism.

Among the differences between the two approaches, the role played by the organizational goals is paramount. In the deductive-rational model, all activities are oriented toward the achievement of the organizational goals. Only the organizational goals should be embodied in decisions and nothing else. Every decision should be justified in terms of the organizational goals. In disjointed incrementalism, the justification for a decision refers to other existing alternatives. Only the differences between alternatives are then evaluated against goals.

Case studies are presented for decision-making rationales and organizational goal assessment within five companies. The relationship between the stated goal and the decision-making rationale is compared with the theories put forward. From the cases it is concluded that both theories are partially valid. Both approaches overlook the content aspect of decision-making where decision criteria appear to play a major role.

Thesis Supervisor: Edward H. Bowman

Title: Professor of Management

THE MARKETING OF A SMALL MANAGEMENT JOURNAL:

A CASE STUDY

by

FRANK K. LYNESS

Submitted to the Alfred P. Sloan School of Management on 12 May 1972
in partial fulfillment of the requirements for the degree of Master
of Science.

ABSTRACT

This thesis concerns the marketing of the Sloan Management Review with particular emphasis on the direct mail advertising of that journal which has taken place since early 1971. The record of marketing decision making is closely examined and is related to theories of decision making described in the literature. The statistics of new subscribers to the journal are analysed and interpreted and a review of the direct mail advertising industry is undertaken. Findings are drawn together into a discussion of the journal's marketing mix and future marketing strategy.

Thesis Supervisor: Alvin J. Silk.

Title: Associate Professor of Management.

ABSTRACT

A TECHNIQUE FOR SCHEDULING PATIENTS TO
SPECIALIST CONSULTATIONS IN A GROUP PRACTICE

Jeffrey M. Lynn

Submitted to the Alfred P. Sloan School of Management on May 12, 1972,
in partial fulfillment of the requirements for the degree of Master
of Science.

A scheme for determining, prior to initial physician-patient contact, which specialist consultations are appropriate for a patient is presented. The scheduling rules were derived from historical data on patients' questionnaire responses and their final diagnoses. Groups of symptoms (as indicated by questionnaire responses) are constructed which indicate the need for a patient to be seen by a physician in a particular medical specialty. The scheduling rules developed are shown to be not as powerful as alternative scheduling methods.

Thesis Supervisor: John F. Rockart

Title: Associate Professor
of Management

MODELLING THE INTERN SELECTION PROCESS

by

Leslie H. Lynn

Submitted to the Alfred P. Sloan School of Management on May 12, 1972, in partial fulfillment of the requirements for the degree of Master of Science in Management.

ABSTRACT

The Tufts-New England Medical Center processes approximately 350 applications for internships each year. The intern selection process requires a large amount of doctor time and the expected increase in the number of applicants prompted this investigation into the admissions procedure.

A clerical scheme for evaluating applicants was developed which replicated the admissions decisions of a committee of doctors with a high degree of accuracy. Suggestions for using this clerical scheme as the basis of an admissions policy are presented.

Thesis Supervisor: G. Anthony Gorry
Title: Associate Professor
of Management

TESTING AND SIMULATION IN PORTFOLIO MANAGEMENT:
FRAMEWORK FOR A SUPPORTING COMPUTER SYSTEM

by

NICOLAS MANKOWSKI

Submitted to the Alfred P. Sloan School of Management
in June 1972 in partial fulfillment of the requirements
for the degree of Master of Science in Management.

A B S T R A C T

The field of portfolio management has witnessed, during the last decade, the continuing development of a wide range of analytical techniques and computer-based information systems. Yet, despite all this sophistication, the results achieved by institutional investors have been disappointing. Very few are the firms that have consistently outperformed the market.

This study develops the hypothesis that the above failure is due to the lack of adequate testing capabilities. From this deficiency has resulted the persistence of a gap between the portfolio managers and the available analytical tools. A computer system supporting interactive testing and simulation is seen as the most appropriate operator to bridge that gap.

A framework is presented to help in the design of such a system. First, portfolio management is analysed as a decision-making process. It is shown that modern management techniques aim at the setting up of decision rules, to handle the more structured problems. However, given the risk-reward structure within which managers must operate, decision rules cannot be feasibly developed without preliminary testing.

The testing process itself is then examined. The role and significance of models is described, along with the sequence of steps to be followed for the creation and testing of decision rules. The requirements that these procedures impose on any supporting formal system are brought out. The need for a computer-based system can then be justified. Special emphasis is put on the study of simulation programs and financial data-bases.

Finally, a set of recommendations for the design of an operational testing system is presented. Considered are the hardware and software components, the organization of a supporting staff, the testing and system usage methods to be adopted by the portfolio managers, and the implications of the system on the operating and control procedures within the firm.

The framework is intended to give a coherent and comprehensive picture of testing procedures and systems. It should result in a better understanding of the field and contribute towards the establishment of sensible long-range systems development plans. In particular, the study can be used by an individual firm, first, to analyse its present procedures and diagnose the most critical gaps and deficiencies, second, to design a system to remedy these specific problems, third, to install, implement and control such a system. The guidelines given are broad enough to leave a large flexibility in the system design phase. The distinction is made between sine qua non requirements and optional features that can be selected by each firm according to its idiosyncracies.

A comparative evaluation of alternative testing systems shows their failure to come not from technical defects but rather from inadequacies in the usage procedures and organizational support. The revamping of these procedures is the key to future success. Of particular importance is the implementation of an on-line conversational interface between portfolio managers and the computer, through visual display terminals. A staff of professional analysts should be organized to counsel and participate in the managers' research process. Finally, each portfolio manager should become a profit center, working within an internal atmosphere of competition and performance.

Thus, the installation of a testing system has broad-range implications that reach throughout the firm's structure and operations. Given proper integration, it should allow most of the other computer-based systems, presently in use, to pass from the state of expensive gadgets to that of effective decision-making support tools. Testing systems are viewed as the catalyst required for such a transformation.

Thesis Supervisor: Malcolm M. Jones

Title: Assistant Professor of Management

A STUDY IN CORPORATE DIVESTITURE
OF PROFITABLE OPERATIONS

by

ROBERT YULANG MAO

Submitted to the Alfred P. Sloan School of
Management on May 12, 1971 in partial
fulfillment of the requirements for the
degree of Master of Science in Management

ABSTRACT

Corporate divestiture has become increasingly an important part of business decision-making, and the number of major divestitures has been running at well above a couple hundred per year in recent years. However, most of the divestitures taken place thus far have involved loss operations, some of which represented quite unsustainable cash drains to the parent corporation. Divestitures of this kind usually placed the seller at severe bargaining disadvantages as shown by a recent thesis at the Sloan School of Management of M.I.T.

It is the belief of this author that corporate divestiture need not always wait until an operation could no longer be considered viable and that selling some profitable or viable operations is within the realm of rational and sophisticated managerial behavior. The behavior of firms selling viable operations is expected to be quite

different from those selling losers.

A normative theory, based on the concept of unbridgeable profitability gaps, has been constructed to show the whys, hows, and whens for corporate divestiture. Unprofitability of an operation was not deemed to be a necessarily prerequisite for divestiture consideration.

Actual histories of ten recent divestitures within four companies are presented and analyzed. It was found that if an operation ought to be divested from profitability gap consideration, then selling while the operation was still viable did afford stronger bargaining position to the seller and permitted more rational decision-making as compared to divesting after the operation had become unsustainable.

While divesting profitable operations was found to be possible and a preferred course of action, given an operation should be divested, all the divestitures studied in this thesis were to a large extent triggered by outside events. What kind of strategic decision system which would always produce timely corporate divestitures is perhaps an area worth further investigation.

Thesis Supervisor: Edward H. Bowman

Title: Professor of Management

MANAGEMENT INFORMATION SYSTEMS:
AN APPLICATION TO FAMILY PLANNING

by
Lesley Ellen Markman

Submitted to the Alfred P. Sloan School of Management on May 12, 1972
in partial fulfillment of the requirements for the degree of Master of
Science in Management.

ABSTRACT

Presented here is the theory, methodology, and design of a management information system to support a simulation model of family planning programs which was developed at M.I.T. by Professor Glen L. Urban. The background of the simulation model and information system is described, as well as the problem definition and analysis, input and output requirements of the information system, design considerations and problems, and the system design itself. Also appended are some details and results of a special-purpose prototype subsystem that was developed and run during January, 1972.

There are many mutually interdependent variables that enter into the management information system design, namely generality, flexibility, ease of use, transferability, speed, cost, efficiency, and ease of implementation. These variables must constantly be traded-off against one another; but since they are not clearly measurable, an attempt to optimize their interaction is a very subjective process.

Thesis Supervisor: Glen L. Urban
Title: Associate Professor of Management

INNOVATIONS IN PETROLEUM MARKETING

Clifford H. Marlar, Jr.

Submitted to the Alfred P. Sloan School of Management on May 5, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

ABSTRACT

The ability of a business to take advantage of opportunities offered by changing conditions is vital to its success. This maxim will be especially pertinent to the petroleum industry during the next ten years since revolutionary changes in the method of marketing gasoline and other petroleum products are emerging.

The retailing revolution has been described as a process of creative destruction. Many new types of business first begin as low status, low margin, and low price operations which are effective competitors of more conventional outlets that have failed to respond to changing customer needs. When these new institutions first appear, the typical pattern is one of institutional conflict followed later by accommodation by the more progressive firms. The resistance to self service gasoline and its adoption by a few major oil companies is a good example of the process. One of the greatest evidences of accommodation in retailing is the increasing phenomenon of scrambled merchandising which occurs when specific retailing establishments take on unconventional lines. This is quite evident in the petroleum industry where the marketing of gasoline is combined with such business as restaurants, grocery stores, ice cream, tourist novelties, tool rental, discount houses, etc. Some of these combinations such as the convenience grocery store offer good ROI and rapid growth is expected.

A fiercely competitive environment seems likely for the petroleum industry during the 1970's. Even though the demand for gasoline will continue to rise, mass merchandisers of TBA, various retail combinations and self service gasoline promise severe competition for the traditional station. To meet this competition oil companies must take steps which will increase the strength of secondary income at their outlets and thus reduce dependence on gasoline for profits. This could mean revitalization of efforts to market TBA and changing from TBA to new product lines at selected outlets. It also seems likely that selling gasoline through the convenience grocery store and free standing self service stations will be included in many oil companies marketing strategy.

Thesis Supervisor: Gordon F. Bloom

Title: Senior Lecturer

ABSTRACTTHE EVALUATION AND PLANNING OF A MARKETING OPPORTUNITY FOR
BRIQUETTED WOOD WASTE

by

SCOTT PHILLIP MASON

Submitted to the Alfred P. Sloan School of Management
on May 12, 1972 in Partial Fulfillment
of the Requirements for
The Degree of Master of Science

Wood-based industries are being compelled, both economically and legally, to abandon traditional solid waste disposition practices. In addition, a declining natural resource base and an increase in the demand for wood based products have combined to underscore the profit potentials of successful wood waste utilization schemes. Briquetting technology has a history of applications to wood waste problems, although markets for briquetted wood products, primarily fuel, have been declining since the early fifties. It is felt that recent developments affecting the Greater Northeast (GNE) market, New England, Middle Atlantic and East North Central states, indicate profit potentials for a briquetted retail fireplace fuel product. This market's worth and growth are estimated through the use of demographic analysis, review of past marketing studies and results of interviews of Boston area buyers and brokers. The market's worth today is put at \$10 million, and is projected to grow at a 10% rate until 1975-1976, when demand is expected to stabilize. Analysis of the profit structure resulting from a projected retail price, indicate sufficient potentials to support all elements of the distribution system. A study of the current leader in the New England retail fireplace fuel market results in a set of criteria for the new product and the associated marketing plan. The marketing plan, which is designed to effect the distribution of the new product, deals with product/package configuration, distribution system, advertising/promotion and pricing strategy. Recommendations, concerning the natural outgrowth of this work, deal with a proposed test market which is supplied from a pilot plant located in the GNE.

Thesis Supervisor: Gordon Falk Bloom
Title: Senior Lecturer

A SYSTEMS APPROACH TO DETERMINING OPTIMAL LEVELS
OF INTEGRATION FOR INTEGRATED CIRCUITS

Bruce A. McDonald

Submitted to the Alfred P. Sloan School of Management on May 12, 1972
in partial fulfillment of the requirements for the degree of Master
of Science in Management

The role of technology within the semiconductor industry has historically been one of developing new and perfecting existing manufacturing processes, techniques and devices. As such, it has been devoted to the perfection of semiconductor device technology, as opposed to improvements at higher systems levels, under the assumption that all major gains in eventual systems economies are based largely at the component level. While this assumption has been found valid in the past, the component-improvement marketing strategy may no longer be the most profitable route for the semiconductor manufacturer.

The first part of this paper deals with manufacturing costs at the component level. A cost function is developed which is used to both analyze present device costs as well as to forecast future costs, both in terms of component cost and in terms of cost per function. Sensitivity of component cost and cost per function to various economic variables, to area per function, to stage yields, and to functional complexity is examined. Using this cost function, an optimum component level of integration can be derived.

The second part considers cost per function from a systems, as opposed to a component, standpoint. The same component cost equation developed in the first section can be incorporated within a systems cost expression to investigate optimal levels of integration within the systems, as opposed to the component, environment.

Finally, a significant departure from current manufacturing strategy is considered: the use of partially good as opposed to totally good devices to be used within subsystems produced and marketed by the semiconductor component manufacturer. The cost and marketing implications of this strategy are shown to be very significant, both for the semiconductor manufacturer and for his traditional as well as future customers.

Thesis Supervisor: Warren H. Hausman

Title: Associate Professor
of Management

Abstract

TITLE: Pricing Policies For An In-House Computer Facility

AUTHOR: Douglas G. Miller

Submitted to the Alfred P. Sloan School of Management on May 12, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

This thesis develops a model of user submission of jobs to a batch computer facility through a bidding process. The effects of this bidding are explored in their relationship to the job turnaround and to the total revenue generated for the facility. This model is then tested for the effects of changes in utilization, capacity, or the minimum price and price increments.

The implications of this model are explored in the context of available microeconomic theory as applied to computer services, and the management policies of a computer center.

The basic hypothesis of the work is that a free market mechanism can successfully resolve the issues of price and allocation of resources, and that the optimum configuration of equipment can be determined as a function of the revenue generated. If the market can work to perform this function, then the issue of pricing can be resolved through operational movements toward equilibrium. The time it takes to establish this equilibrium, and the ability of the system to respond to changes in demand are also explored.

Discriminatory pricing is explored as a procedure for optimizing computer net value for the organization. After considering the impact on revenue, costs and usage patterns, a model is developed to determine if discriminatory pricing is a valid equilibrium condition. The variables influencing the movement toward equilibrium, or forcing the system into some other equilibrium are explored.

Thesis Supervisor: Malcolm M. Jones

Title: Assistant Professor of Management

AN APPLICATION OF A DECISION SUPPORT SYSTEM TO BUDGETING

by

John Shalloe Mills, Jr.

Submitted to the Alfred P. Sloan School of Management on
May 17, 1972 in partial fulfillment of the requirements for the degree
of Master of Science.

ABSTRACT

This thesis is a case study of an application of a decision support system to budgeting in a manufacturing firm. The three interacting elements, a decision maker, a computer (both hardware and software), and a management problem or decision task are the basic components of the decision support system.

The actual project took place in the parent company of a corporation which had nine foreign subsidiaries. The management problem was their manual budgeting process which was not operational due largely to the quantity of data that had to be clerically processed with each revision, and inconsistent application of methods for consolidation.

A decision support system was designed and implemented on an interactive commercial time-sharing computer service and employed a proprietary software package instead of a higher level language. The resultant system provided standardized budget formats, provided all the data handling for preparation of budgets with monthly estimates, and provided consistent application of parameters and algorithms for aggregation on a regional basis and consolidation on a corporate basis. In addition, the decision support system provided a determinate simulation model which permitted the decision maker to test alternative revenue and expense estimates interactively.

As a result of the project the budgets were prepared in a much shorter time, more accurately, and in greater detail. In addition the process of budgeting was improved. The process became iterative with more

involvement of subsidiary managers and with effects on the consolidated budget made explicit. The thesis discusses the effectiveness and impact of the system in detail.

Observations on the use of the system revealed two interesting facets of user-system behavior. First, the decision maker often used a specific criteria, corporate consolidated profit, for evaluation of alternative plans. The discussion uses the increased knowledge about decision processes to focus on the potential for improved design and evolution of decision systems. Second, observations on how the system was used revealed problems with the user-system dialogue and the system's display features. The findings reflect the criticality of man-machine communications.

The conclusions, drawn from the experience of the project and from the observations of the use of the system, make some progress toward more effective and successful decision support systems.

Thesis Supervisor: Michael S. Scott Morton

Title: Professor of Management

L. D. Papademos, SM Thesis (Prof. Little)

"Simulation of Traffic Networks: Analysis and Application"

A systematic method of analyzing and evaluating the logical structure data base, and output response of a stochastic simulation model is formulated and then applied to investigate the dynamic behavior and the reliability of a simulation of traffic networks.

A critical examination of possible methods of analyzing stochastic simulation models concludes that autocovariance and spectral analysis provide an appropriate theoretical framework for the type of processes under study, greater insight into the dynamic behavior of a simulation, rigor for a more accurate interpretation of the results, and relative computational economy. A comprehensive summary of the theory and techniques of spectrum and autocovariance estimation is presented.

An updated version of a simulation program of traffic networks is developed, and the outlined methods of analysis are applied to test whether the model operates according to its basic assumptions. The dynamic behavior of the model's major component is investigated, and the variability of the simulated results is examined.

To evaluate how accurately the model approximates a real network, a series of experiments were performed to measure the travel times of vehicles along selected routes and a street segment of a traffic network in the Boston area. A comparative analysis of the real and simulation-generated data shows a satisfactory agreement for both average values and operational characteristics.

An alternative flow-and-signal scheme for the real network is simulated and found to improve the network's performance by thirty per cent according to a chosen measure of effectiveness. The traffic authorities have accepted a proposal for implementation of the simulation's recommendation.

INDUSTRIAL NOISE ABATEMENT MARKET

by

YU CHUL PARK

Submitted to the Alfred P. Sloan School of Management on February 28, 1972, in partial fulfillment of the requirement for the degree of Master of Science.

ABSTRACT

Recently, a new industrial noise abatement market has been developed as a result of new legislation, the Occupational Safety and Health Act (1971) and the Walsh-Healey Act (1969). To support the study of this new market, various industrial noise problems, contents of this legislation and the importance of proper enforcement are discussed ~~in following chapters~~. Based on that information market potential is estimated and an attempt is made to forecast sales volume over time.

Thesis Supervisor: Philippe A. Naert

Title: Assistant Professor of Management

IMPLEMENTING MANAGEMENT SCIENCE:
AN ANALYSIS OF THE PROBLEM AND A SUGGESTED STRATEGY

Carl D. Peterson

Submitted to the Alfred P. Sloan School of Management on May 5, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

For the last fifteen years managers of American business have been attempting to use computer-based technology to improve the performance of their enterprises. This technology holds great promise; literature on the subject depicts almost unbounded opportunities for its use.

The promise remains unfulfilled. In recent years management literature has looked closely at the failures and frustrations of applying computer-based technology and model-based analysis to the management of business. Fingers of blame have been pointed at the managers for their failure to learn and understand the new technology and at management scientists and computer specialists for their failure to learn and understand what managers need. Many additional causes and cures have also been advanced.

This thesis will examine the failure of computer-based technology and mathematical model-based analysis in management. The focus will be on the implementation problem: the transfer of the technological innovation from the technician to the manager.

The term "management science" will be used as a label for the technology to be examined. A definition is presented in the Introduction. It generally includes Operations Research and Management Information Systems.

The thesis has three objectives:

1. To provide a framework which attempts to encompass all facets of the implementation problem;
2. To provide actual case examples of how implementation problems occur;
3. To provide an operational strategy for coping with the implementation problem.

For objective #1, literature research was performed. The search revealed that no comprehensive framework existed. Most authors presented only one or two aspects of the problem. The framework developed in this thesis has three major sections: Human Factors, Organizational Factors, and Technical Factors.

For objective #2, empirical research was performed. Seven companies were interviewed and seven miniature case studies prepared and analyzed. The cases show that the problem is extremely complex and that it exists in each firm in a unique form.

For objective #3, an operational strategy was developed. It makes use of the framework developed in objective #1, and the ideas of complexity and uniqueness developed in objective #2. It calls for a situational analysis, a transformation of that analysis into its implications, and the development of an initial plan. The use of the strategy is demonstrated by applying it to one of the miniature cases presented in the thesis.

Although it was never an explicit objective, it is also hoped that this thesis can contribute in some way to improving implementation by calling attention to the seriousness of the problem and by demonstrating its pervasiveness.

Y

Thesis Supervisor: Warren H. Hausman
Title: Associate Professor of Management

COMPARISON OF TECHNIQUES USING
FINANCIAL RATIOS AS PREDICTORS OF FAILURE

by

ROGER LEE POWELL

Submitted to the Alfred P. Sloan School of Management on May 12,
1972 in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

The recent poor performance of our nation's economy has been marked by a rash of business failures in all sectors. One industry which has been particularly sensitive to economic down turns in the past is the nation's railroad carriers. In 1970, five railroads petitioned the courts for bankruptcy under Section 77 of the National Bankruptcy Act. One of these failures, The Penn Central Transportation Company, has received the most publicity mainly due to the fact that it is by far the nation's largest railroad carrier and also due to the political consequences it has wrought.

This thesis attempts to examine the efficacy of developing a statistical predictive tool, primarily through the analysis of common financial ratios, to be used in forecasting impending problems, and by using the railroad industry as a model. The purpose is to begin to specify and define the most useful data for establishing a predictive device to inform those responsible and interested parties.

Thesis Supervisor: Jarrod W. Wilcox
Title: Assistant Professor of Management

A MODEL OF THE COST OF SOFTWARE DEVELOPMENT
FOR THE APOLLO SPACECRAFT COMPUTER

by

Daniel Allen Rankin

Submitted to the Alfred P. Sloan School of Management
on May 12, 1972 in partial fulfillment of the requirements for
the degree of Master of Science.

ABSTRACT

The Charles Stark Draper Laboratory of the Massachusetts Institute of Technology has developed and implemented the primary Guidance, Navigation and Control System for the Apollo manned spaceflight project. This thesis examines the software portion of the project to determine a relationship between cost and output of computer programming.

This thesis is primarily a historical case study. The many special conditions of the Apollo software make it difficult to generalize the specific results to other programs. However, the form of the model may be generally useful. Further, case studies of computer programming costs are sufficiently rare that the data should be useful as a reference for managers faced with preparing estimates for software projects.

The methodology employed is quite simple. Accounting data and information on duties of organizational groups are combined to yield costs of various functions in each six month period. Data is available on timing and content of computer programs released. From this data, logic and arithmetic are used to evolve the form and coefficients of the model. The prediction of software cost per period is made on the basis of two measures of output, the total words of coding released in each period and the number of new words of coding in each period.

The following equation closely models the cost of software development in each six month period from 1961 through 1970.

$$\bar{Y}_t = 0.5\bar{Y}_{t-1} + 0.5Y_t = \text{Smoothed predicted cost in period } t$$

Where

$$Y_t = A + C_t + T_t + \text{Comp}_t + D_t + M$$

Where

$$\begin{aligned} A &= \text{Analysis cost} = \text{constant cost per period} \\ &= \frac{(\$39.08/\text{new word}) (\text{total new words in project})}{(\text{total periods in project})} \end{aligned}$$

$$C_t = \text{Coding cost} = (\$48.92) (\text{new words released in period } t)$$

$$T_t = \text{Testing cost} = (\$13.43) (\text{total words released in period } t)$$

$$\text{Comp}_t = \text{Computer cost} = 1.04(A + C_t + T_t)$$

$$D_t = \text{Documentation cost} = 0.17(A + C_t + T_t)$$

$$\begin{aligned} M &= \text{Management cost} = \text{constant cost per period} \\ &= \frac{(0.11) (\text{total project } A + C + T)}{(\text{total periods in project})} \end{aligned}$$

Thesis Supervisor:

Malcolm M. Jones

Title:

Assistant Professor of Management

ABSTRACT

Title: Strategic Change in Financial Intermediaries

Author: Lucille Donna Roseman

Submitted to the Alfred P. Sloan School of Management on May 12, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

This thesis studies strategic change in financial intermediaries. An effort is made to determine what factors are important in management's strategic decisions. These decisions pertain to the relation between a firm and its environment, the product mix which a firm will produce and/or the markets to which it will sell. Emphasis is given to behavioral variables as well as economic variables in the process of organizational decision making.

Theories of financial intermediation, corporate strategy, and organizational behavior are reviewed. With this as background, case studies are presented of strategic decisions made by the managements of financial intermediaries. The data for these was gathered by interviewing persons involved in the decision making as well as consultants, staff persons, and observers. Background reading for the cases included annual reports, speeches, and financial journal articles.

The scope of the decisions studied was broad: two cases of one-bank holding company formations, one case of a mutual fund formation by an insurance company, and one case concerning the start of a consumer credit card operation by a bank. The implementation and control stages of the changes were included in the studies.

There are several conclusions to be drawn from the study. Strategic decisions in financial intermediaries are the result of continuous intelligence activity and evaluation of opportunity in the environment. Exogenous events may trigger the timing of these decisions in some cases. Governmental regulation is an important part of the environment. Strategy of the intermediary can help bring about a regulatory change; a regulatory change can bring about a change in strategy.

Alternative generation in the formulation of strategic decisions is very limited. In the implementation stages, alternatives are more numerous. Alternatives are looked at

sequentially in most cases, sometimes compared, as in the implementation stage. The alternatives chosen, in all cases, are similar to previous alternatives or procedures which produced success for the firm in the past or are similar to those alternatives which other firms are choosing or about to choose.

The goals of the firm are a result of the firm's stage in its life cycle. Its goals are also influenced by whether it is a stock or mutual company. The choice of an alternative did generally fit the goals of the firm. There are instances of goals being attended sequentially.

.. There was decentralization of decision-making in the strategy implementation stage, but the presidents of the companies made the strategic decisions.

Thesis Supervisor: Edward H. Bowman
Title: Professor of Management

CONSULTING FOR A CITY GOVERNMENT:

A Conceptual Framework and Some Determinants of Success

by

Yoram Rosenberg

Submitted to the Alfred P. Sloan School of Management on April 28, 1972 in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Management.

ABSTRACT

The purpose of this dissertation is to contribute to the understanding of the consulting relationship between a consulting organization and a city government in particular, and to the theory of consulting in general. The specific issue being dealt with is that of what contributes to, or hinders, the successful outcome of such a consulting relationship.

In the dissertation a general conceptual framework for the characterization of the consulting process is presented. The framework is developed along three dimensions - the elements of the consulting system, the time, and the variables. The elements of the consulting system are defined to be the client, the consultant and the problem which the consultant is engaged to solve. Along the time dimension a distinction is made between three phases of the consulting process. Those are characterized as the formulation of the problem (Conceptualization), the development of a solution (Design), and the implementation or usage of the solution (Implementation). The variables are separated into three groups. These are the independent (initial), intervening (intermediate), and dependent (end-result) variables. The initial variables are defined as any resource, condition, technique or characteristic, which may affect the process of consulting. The intermediate variables are defined as the levels of task-oriented knowledge, motivation and activity of the parties involved. The end-result variables are defined as measures of success of the consulting effort. Using this three dimensional framework, any factor which ought to be considered in the study of consulting can be defined with respect to what it is, what it affects, how and when.

The validity and worthwhileness of the view presented by the framework and the differentiations of each of the framework's dimensions, are examined in several ways. The differences between the client's and the consultant's perceptions of all the variables were studied, as well as the changes in the intermediate and end-result variables

from phase to phase, and how the variables associated with the client differed from those associated with the consultant. In addition, a causal model of the intermediate and end-result variables was developed. The framework was shown to be useful to participants and for theory development as well, and the differentiations of the dimensions were found to be substantiated by the findings.

The framework gives rise to several groups of hypotheses corresponding to links between and within groups of variables within and across phases. Particular hypotheses concerning the impact of specific characteristics of the problem on the client's motivation in Conceptualization are proposed and tested. It was found, for example, that the client's commitment in Conceptualization was increased the better he knew what the study was about and what it could do for him, and the sooner he expected the benefits associated with its outcome to materialize.

The analysis led to the identification of several factors which contributed to the success of the consulting effort. For example, it was determined from the model of causal relationships that success in the Conceptualization phase depended only on the party which carried out the activities of that phase. Success in Design depended on the client as well as on the consultant, even when the consultant was the party which carried most of the work load in that phase. Success in Implementation depended only on the client, even when the consultant was the one to carry out implementation. It was also found that the Conceptualization and Design phases were more successful when the consultant performed them, and the Implementation phase when the client did. The reasons behind those findings, as well as additional determinants of success, on the level of the individual study and of the consulting relationship as a whole, are presented and analyzed.

The data base consisted of fifty-three studies which were conducted by one consulting organization for eight departments of an administration of a large city. A questionnaire was developed to collect the necessary data and was personally administered in more than one hundred interviews to members of the client and consulting organizations.

The general results obtained suggest the need for improvements in the consulting relationship in several areas. Recommendations regarding the improvement of communication, participatory work habits, the selection of problems to work on and other areas are presented. As a result of insights developed during the research, a suggestion for a technique for the modeling of the consulting process has been advanced.

Thesis Supervisor: John F. Rockart
Title: Associate Professor of Management

ABSTRACT

THE MODERN VOLUNTEER ARMY - AN APPROACH TOWARD ATTAINMENT

DOUGLASS ALFRED SEDGWICK

SUBMITTED TO THE ALFRED P. SLOAN SCHOOL OF MANAGEMENT

ON 11 APRIL 1972 IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

This thesis starts with the premise that the Army, in order to gain its goal of being all volunteer by June 1973, must develop a marketing program to "sell" the Army to the youth of America.

Interviews were conducted with the potential Army market (defined for the purposes of this paper as high school senior boys and girls) to determine:

- a. What are they looking for in an occupation?
- b. What is the current Army image?
- c. Who influences them most in job selection?
- d. What changes would they most like to see in the Army?

Two hundred and fourteen seniors from six high schools were interviewed. The six schools were from different geographic and socioeconomic areas to insure that a cross-section of students was interviewed.

The thesis concludes:

a. An all volunteer Army is attainable if a viable marketing program is developed based upon a nationwide market survey utilizing techniques similar to those used in this study.

b. The Army currently appeals to a small percentage of all socioeconomic levels, although this appeal is somewhat greater in low income areas.

c. The potential enlistee from different geographic areas or different socioeconomic backgrounds may be looking for different things in an occupation. The Army must be aware of these differences and tailor local programs to fit the situation. This requires an approach similar to that used for segmented markets.

d. If the length of enlistment were reduced to one or one and one half years, Army appeal would be greatly increased to all socioeconomic backgrounds with relatively minor changes to the existing make up.

e. The two most desired changes to the Army expressed by the respondents were:

(a) Enlistees should be permitted to live near home, and go home more often.

(b) Enlistees should be permitted to select their own type of work.

f. It is generally accepted by the potential market, that the Army helps an individual mature and gain a sense of responsibility.

That the Army does provide these characteristics will have high appeal to the large portion of the potential market who are undecided as to occupation. An advertising program stressing that the Army will provide an individual the chance for increased maturity and sense of responsibility while he decides on an occupation would find wide acceptance among the potential Army market.

Thesis Supervisor: Gordon Bloom

Title: Senior Lecturer

INTERACTION BETWEEN AGGREGATE AND DETAILED SCHEDULING IN A JOB SHOP

by

Joel Shwimer

Submitted to the Alfred P. Sloan School of Management on May 4, 1972
in partial fulfillment of the requirements for the degree of Doctor
of Philosophy.

This dissertation is concerned with the different levels of decision-making in the scheduling of a production facility and how interaction between these levels can be used to improve the overall quality of the decisions being made. Although the particular models and modes of interaction will be placed in the job shop context, the general methodology being employed can be useful in numerous other situations. In effect, this work is an attempt to synthesize and advance the work of many others who have studied only isolated portions of the job shop scheduling problem. Improved overall results can be achieved by treating the separate parts of this problem within a single framework, thereby considering the ways in which these parts are related.

A "total" model which incorporates both the aggregate (e.g. hiring, firing, use of overtime, and allocation of workers to machine groups) and detailed (e.g. what job is placed next on each machine, and at which machine each worker works next) decisions of job shop scheduling is constructed. The size and complexity of this model preclude its direct solution. However, the model delineates the basic structural aspects of the problem that must be considered in developing methods for its solution.

This model is then partitioned into an aggregate level model and a detailed level model. The aggregate model, although similar to some past work in this area, extends the applicability and usefulness of such a planning tool. A more realistic aggregate model of the shop is possible by considering a number of worker skill classes and machine groups, each with different capabilities. In addition, an important step has been taken towards the disaggregation of the solution, thus making implementation much easier. Although the aggregate model, as formulated, is a mixed-integer linear program, the linear approximation to this model can be solved quite efficiently. Using appropriate rounding techniques this becomes a good approximation to the mixed-integer model.

The detailed model is still of sufficient size and complexity to

preclude the use of an optimal solution-seeking method. Therefore, heuristically based job dispatching (e.g. COVERT) and labor assignment rules within a simulation framework are used to obtain a good, but not necessarily optimal solution.

Iteration between these two submodels presents a method for obtaining a good solution to the "total" model. Each submodel requires certain information which is determined in the other submodel. A number of procedures for passing the necessary information and then utilizing it are proposed. This interaction between the two models, or levels of decision-making, has usually been ignored or been performed only by default in much of the job shop scheduling research.

A hypothetical job shop is used as the experimental environment within which a number of the proposed methods of interaction are tested. The results of this experimentation confirm that improved overall performance in a job shop can be obtained if the aggregate and detailed scheduling are performed jointly or by means of some reasonable coordination scheme between these two subproblems of the total job shop scheduling problem.

Thesis Supervisor: Paul R. Kleindorfer

Title: Assistant Professor of Management

ABSTRACT

AN INVENTORY MODEL FOR STYLE GOODS

by Richard St. G. Sides

Submitted to the Alfred P. Sloan School of Management on May 12, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

Style Goods are merchandise that becomes obsolete a few months after it is launched into the marketplace not because it is perishable in the sense that food quickly becomes unsalable but because the customers are willing to buy only the latest style or fashion. The product life-cycle has thus a rapid growth segment at the start followed immediately by a rapid decline without any stable and stationary 'mature segment' in the middle; it is for this relatively stationary and stable segment that all well-known forecasting models are designed and in consequence a new and different model is needed to control the inventories of style goods.

The prototypical example of style goods is ladies' clothing. With the generous cooperation of a retailer in this field who obtains most of his business by mail, the mail-order demand records for each of 18 weeks of 126 items from his Ladies' Department have been studied and used to test a variety of models that may be thought to describe the probabilistic behavior of the demands for his merchandise (or, in some cases, the probabilistic behavior of his forecasts of these demands) for the whole season. The mail-order case is simpler than the typical retailer's problem since demand is entirely independent of the in-season decision variables, which are the retailer's actions in maintaining availability, in revising his display, in advertising, in changing prices, or in 'helping' the customer choose her purchase. Whether a solution to the mail-order case can be extended to the general retailing case is a matter for further research.

The data were found to be incompatible with the hypothesis that the ratios of successive forecasts are log-normally distributed. The logs of these ratios are better fitted with a Student's t distribution that has from 4 to 7 degrees of freedom, meaning that the logs of the ratios are conditionally Normal, the condition being that the parameter of the Normal distribution is not a (known or unknown) constant but is a random variable obeying a Gamma distribution. The parameters of the Gamma distribution can be estimated; the algebraic consequence of removing the conditioning by integration is a Student's t marginal distribution. The use of a ratio of successive forecasts was intended to create a statistic that is invariant to volume of sales but it is demonstrated that the variance decreases proportionally with an increase in the sales volume.]

As an alternative data-generator the simple Poisson process to describe the sales of each item given the gross total of transactions in each period fits the data only to a limited degree; the ratio of variance/mean for the sample is strictly greater than 1. [An infinitely

compound Poisson model can be fitted to the sample second moment to yield a negative-Binomial distribution. If transactions to date are regarded as a Bayesian sample from which the unknown parameter of a Poisson process is estimated, the unknown parameter having a Gamma distribution by assumption, the Poisson process conditional on the unknown parameter is unconditionally a negative-Binomial distribution; this resolution is the one adopted. The Poisson model originates as an approximation to the Binomial distribution when p is very small and n is very large; the dimension of this model is thus not time measured in days or weeks but transactions (trials in binomial terms) which have the characteristic that busy weeks and slack weeks do not cause a change in parameters. What the model does is to allocate total demand to the various items; total demand is relatively easy to predict exogenously and being a very large number has a very small coefficient of variation.

The decision rules address the questions of how much to order and when to commit to a final order. 'How much?' is decided by a newsboy solution (with asymmetric linear costs for overage and underage) that minimizes the expected cost of uncertainty; 'when?' is decided by considering the tradeoff between the benefit of delay (because the cost of uncertainty decreases in a predicted pattern with time) and the cost of delay (because back orders mean extra costs and because the risk of vendors defaulting increases). This tradeoff can be made whether there are multiple chances to reorder or only one.

A means to forecast returns, which are regarded as involuntary purchases, is developed so that the quantity to be purchased from a manufacturer can be adjusted.

The model is computationally simple so that it can readily be made the heart of an inventory control system; the demands on the user for information and for criteria to be used in the decision rules are modest. Its mathematical base is rigorous and the assumptions that are needed are not restrictive; one is that customers buy only one piece of each item at a time; another is that they are unaware of actual availability or of the results of other retailer actions in his store subsequent to his mailing the catalog; the third is that the forecast of total transactions for the season is reasonably accurate and is updated at each review opportunity so that it contains no systematic error; the last is that the interaction between sequential decisions is minimal. To the extent that these assumptions are unsound the model becomes imprecise but it is believed that it will yield very good approximations to best forecasts and optimal decisions for modest departures from the assumptions. Moreover, the true test of a model's usefulness is whether or not its use would significantly improve operations over the best alternative methodology. Although no detailed comparisons with current policy have been possible, it would appear that the model presented here would significantly improve operations.

Thesis Supervisor: Warren H. Hausman
 Title: Associate Professor of Management

An Analysis of School District
Regionalization in Massachusetts

by

James M. Staffaroni

Submitted to the Alfred P. Sloan School of Management
on May 12, 1972, in partial fulfillment of the
requirements for the degree of Master of Science in
Management.

Abstract

The organization of school districts in Massachusetts has evolved into a complex system of school committees and superintendents with overlapping jurisdictions and confused lines of authority. The major cause of this complexity is the growth of partially regionalized districts. Two or more towns agree to form one school district, which most often serves only the secondary level grades. The towns continue to operate their own, separate elementary school districts. Thus, three school authorities exist where there had previously been only two. Throughout the State, the number of school districts has increased from 351 to 392 since the passage of the regionalization law.

This thesis attempts first to find some reasons for the predominance of partial over full regionalization, i. e., comprising all grades. A cost analysis is performed to describe some economic and educational reasons for this development. Secondly, suggestions are made which will help State education officials encourage the formation of fully regionalized districts. A new direction is needed in organizational planning in education with a shift in emphasis from regional or district to State-wide considerations. In addition, new efforts must be made to improve the relationship between the Department of Education and the Legislature, which is the obvious source of incentives for full regionalization. Finally, local school officials must be made aware of the benefits to be gained by streamlining the organizational structure of schools in the State.

Thesis Supervisor: Paul R. Kleindorfer

Title: Assistant Professor of Operations
Research and Management

ABSTRACT

Towards a Greater Understanding of Neighborhood Health Centers

by

Gayle Ellen Stone

Submitted to the Alfred P. Sloan School of Management on May 12, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

Neighborhood health centers (NHC's) have experienced a rapid increase in numbers since the first was funded five years ago. There are now over 40 such ambulatory clinics in the Greater Boston area, providing low-income populations with much needed health care. Such community-based centers often involve residents of the area in their decision-making processes. The financing of this recent growth has been primarily from large federal grants which are disappearing now as quickly as they appeared. The future of NHC's depends on their ability to locate new revenue sources to support the level of services they provide. Additionally, to remain autonomous, they must assume responsibility for their own survival rather than rely on others.

This thesis is an attempt to clarify what a NHC looks like today and what an idealistic image might be. The author compares the two images and explains the differences and how they can be narrowed. The approach is a managerial one, which explains organizations, like NHC's, in terms of a model. The theoretical model used views organizations as systems, interacting with their external environments. The important conceptual variables used are the goals, the design, and the management processes of organizations.

The process of "problem-finding" for NHC's yields insights into the large number of uncontrollable and slow-changing environmental variables facing NHC's (such as professional reward systems) which the NHC would like to change. Those variables which are potentially manageable by NHC's are unfortunately fewer,

but are still important for survival. They include clarifying ambiguous NHC goals, actively searching the relevant NHC environment, designing appropriate organizational structures and reward systems for health centers, and managing the aggregation and allocation of NHC resources in a responsible, programmatic manner. The author proposes what would be her action plan as a NHC manager, which is based on managerial theory and the NHC models presented.

Thesis Supervisor: John F. Rockart

Title: Associate Professor
of Management

ABSTRACT

Title: Model for Decision Making Distribution of Federal Student Assistance Funds

By: Gordon Tavis, OSB

Submitted to the Alfred P. Sloan School of Management on May 5, 1972 in partial fulfillment of the requirements for the Degree of Master of Science.

In 1959 the Congress of the United States wrote the first of the Federal Student Assistance programs into law. Since that time National Defense Student Loans, then College Work-Study Funds and Educational Opportunity Grants have been distributed to institutions of higher education. This distribution process contains a complex of decisions of many kinds made on many levels. To describe that decision process in model form is the task of this thesis.

As background, the elements of a decision are investigated in order to determine whether they fit the criteria for a model. Once that has been established, the objectives of the programs, the values they contain and the philosophy of financial aids are assembled to provide a basis for the distributive decisions.

The Fiscal Year 1973 application process is used as a case study to describe the manner in which funds are currently handled. A critique of that process is offered before looking at a possible method of modeling that involves the computer. Advantageous trends of the past years are identified and pitfalls of the past are pointed out. These provide the basis for the judgment that takes place: Should the process be modeled as it historically stands, or should the process be altered to fully employ the capabilities of the computer? The critique leads the way to the second choice.

The plan and strategies for accomplishing such a model are determined. The establishment of scales of effectiveness, which can be used to evaluate the degree to which each institution fulfills the program objectives, is the most critical portion of this thesis. While the computer is used for that evaluation, it is also programmed to project a variety of institutional statistics, specifically the Projected Institutional Need. Through man-machine interaction within the model, the projected amount of institutional need is verified. At that point the computer, on a regional basis, distributes the funds

to each institution in terms of the total dollars available to the region and in terms of each institution's effectiveness rating.

The model thus developed describes the decision process involved in the distribution of Federal Student Assistance Programs with the computer as a participant in decision making.

Thesis Supervisor: Paul R. Kleindoefer

Title: Associate Professor Of Operations Research and Management

ABSTRACT
WATER QUALITY PLANNING IN A RIVER BASIN

by
ANTHONY CRAUFURD TAYLOR

Submitted to the Alfred P. Sloan School of Management on May 12, 1972 in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

The problem of how to manage water quality in a river basin is addressed. A conceptual model of a river basin is examined to discover in what ways a management system may be brought to bear to improve the quality of the water. The model comprises four subsystems: physical, economic, social and ecological. There are many controls in the economic, physical and even social subsystems which may be used to alter water quality. The task is one of designing a water quality management system to support an agency in choosing and implementing these controls.

The management system can be characterized as two processes: there is a policy formation process for the resolution of social choice issues and a management control process to plan the best way to realize the policy objectives and to control the implementation of the plan. The policy formation process requires information about possible river uses, about the criteria relating each use to water quality, about the social value of each use, and about the social costs of achieving various water quality levels, preferably the least social cost; there are many possible waste abatement programs that could satisfy a given water quality standard. The least cost or efficient solution is very difficult to obtain since it depends on the present and future waste abatement technology of polluting industries and municipalities as well as on economic growth. Identification of least cost waste abatement programs thus provides the agency with an information problem, while persuading waste dischargers to adopt a least cost program presents an incentive problem.

The management control process is given the task of solving both the information and incentive problems and passing the least cost information back up to the policy making process. A valuable tool in this endeavour is the water quality model which relates water quality at specified quality posts along the river to the effluent discharged. Water quality models in the literature often have an

"optimizing" component which allows identification of the least cost configuration of effluent discharges and collective facilities to achieve a given set of quality standards, as long as the costs of all possible configurations are known. In practice these are usually not known, at least not centrally.

Solutions to the information and incentive problems lie in the selection of waste abatement controls. Most controls in common use today, such as effluent or treatment standards, or the provision of government-owned treatment facilities fail to solve either problem and hence rarely lead to efficient (least cost) waste abatement. Some controls, namely effluent charges and discharge warrants, manage to solve the incentive problem, thus achieving what is called zone efficiency; that is, at each quality post the water quality which results is attained at least cost. Basin efficiency, which is an efficient sharing of waste abatement costs among different zones along the river, can be ensured only if the information problem has been solved.

A scheme is proposed for implementing effluent charges which solves to some extent both the information and the incentive problems. It is called the rent allotment scheme and embodies an agreement between the agency and the dischargers on an effluent charge or rent and on an allotment for each discharger. The agreement is struck in a bargaining process or game which closely imitates an algorithm called the rent allotment algorithm; this algorithm guarantees an efficient solution by satisfying the Kuhn-Tucker conditions for the efficiency problem. The shadow prices may be interpreted as water quality prices for each zone. This scheme can be extended to provide a market for allotments in terms of these water quality prices. This market serves also as a mechanism for local participation in setting water quality standards.

The major features of the policy-planning relationship are reviewed, the problem areas identified, and a planning and control system proposed which attempts to solve these problems and draw the parts of the process together into a more concrete and implementable form. The heart of this system is a quality/profit center which integrates the agency and the basin inhabitants into a common concern for using the region's funds to manage water quality in the best way possible. An accounting structure is designed to support the quality/profit center.

Thesis Supervisor: Zenon S. Zannetos
 Title: Professor of Management

THE IMPACT OF AN INTERACTIVE RISK ANALYSIS MODEL ON THE NEW VENTURE PLANS OF A GROUP OF ENTREPRENEURS

by

Richard C. Thurber, Jr.

Submitted to the Alfred P. Sloan School of Management on May 12, 1972, in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

The purpose of this thesis was (1) to develop a computer model which would assist an entrepreneur in analyzing a new venture and preparing a business plan, and (2) to test this model on a group of entrepreneurs and measure its effectiveness.

The model queries the entrepreneur to determine his estimates of probability distributions of key parameters of the proposed venture. These parameters include such variables as sales estimates, selling price, costs, financing plan, etc. By using Monte Carlo simulation techniques the model constructs probability distributions of future balance sheet and income statement items and of return on investment to both the entrepreneur and outside investors.

A group of ten entrepreneurs used the model, filling out questionnaires both before and afterwards. The questionnaires were designed to test the following hypotheses:

- (1) Entrepreneurs can be taught to use the model and feel "comfortable" with it in a relatively short amount of time.
- (2) Using the model, an entrepreneur would test more alternative venture plans than he would without the model.
- (3) Using the model will change the entrepreneur's assessment of the risk-return relationship of his venture,
- (4) The model will cause the entrepreneur to change his

goals regarding the venture capital deal he is trying to negotiate.

None of the four hypotheses could be accepted in this experiment. Although nine of the ten entrepreneurs tested indicated that they believed such a model could be a valuable tool to them, this experiment was unsuccessful because of limitations of the model itself and limitations in implementing the model.

First, the model was simplified to the point that it did not describe many of the ventures realistically enough so that its results could be used for meaningful analysis. Secondly, the output formats of the model were so restricted that the model would have been very difficult to use even if the output results had been accurate. And finally, there was not time in the experiment to properly implement even the simplified model so that the entrepreneurs would be willing to use it seriously.

Thus the original goals of this thesis were not borne out, but the insights gained in this study may serve as a guide to others who seek to implement interactive computer models.

Thesis Advisor: Glen L. Urban

Title: Professor of Management

ABSTRACT

CHANGE IN CORPORATE STRATEGY: A CLINICAL STUDY

by

JOHN B. WINCH

Submitted to the Alfred P. Sloan School of Management
on May 12, 1972 in Partial Fulfillment
of the Requirements for
The Degree of Master of Science

This thesis examines the applicability of normative and descriptive theory of the firm in the areas of strategy, organization and marketing. Two cases were investigated in the area of strategy; a small integrated manufacturing concern and a division of a decentralized conglomerate. Only the small firm was considered in the investigations of organization and marketing. The documentation technique used is to present the results of interviews at the firms, followed by an analysis of the applicability of various theories to the situation actually found in the firms studied.

The conclusion reached is that the descriptive theory is generally adequate and operational for a large and integrated manufacturing concern, but further work needs to be done to specialize this theory to the characteristics of a division of a decentralized conglomerate.

It was found that normative theory was not utilized due to lack of a perceived need for its use and diversion of management attention to operational problems.

Thesis Supervisor: Edward H. Bowman
Title: Professor

CORPORATE PLANNING IN JAPAN

BY

SHINICHIRO YOSHIMURA

Submitted to the Alfred P. Sloan School of Management on May, 1972 in partial fulfillment of the requirements for the degree of Master of Science in Management.

ABSTRACT

These days corporate planning has been widely accepted in the U.S. business world. Ever since the late 1950's many Japanese corporations have eagerly introduced it. However, in most of the cases where companies applied corporate planning systems directly to their management, they failed to use them effectively.

This thesis deals with two basic questions about corporate planning related to Japanese industries:

1. How is corporate planning implemented by the American business community?
2. What are the causes of failure in adopting corporate planning techniques in Japanese companies?

Data for this study was obtained by researching the literature on current theories of corporate planning and the managerial environment in Japan, through personal interviews with the planning staff in an American company, and by means of questionnaires to a Japanese firm.

The literature survey on theories of corporate planning established that there is no widely accepted theory. One version of the corporate planning model was settled on by the author as the basis of comparison within the cases.

Using the results of those comparisons and other sources of information, the following conclusions were reached:

1. In American business firms, the current practice of corporate planning is still in the experimental stage. Most of the large companies use various techniques which are revised as the theory progresses through practice. However, some companies are using a corporate planning system which works effectively.
2. The causes of failure in adopting corporate planning to Japanese firms are due mainly to a misunderstanding in concept and, in part, due to the lack of recognition of a real need for corporate planning, the influences of traditional management systems, and the way Japanese think about the planning process.

Thesis Supervisor: Michael S. Scott Morton

Title: Associate Professor of Management



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